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KNOWLEDGE

AN ILLUSTRATED MAGAZINE OF SCIENCE

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Edited by A. COWPER RANYARD.

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KNOWLEDGE
AN
ILLUSTRATED MAGAZINE
OF
SCIENCE, LITERATURE, & ART

LONDON: NOVEMBER 1, 1888.

TO OUR READERS.

THE representatives of the late Mr. R. A. Proctor, acting for the benefit of his widow and children, have agreed for the sale of KNOWLEDGE to Messrs. W. H. Allen & Co., publishers, of Waterloo Place, who have already received promises from many of Mr. Proctor's scientific friends to contribute to its pages. The original idea of Mr. Proctor with respect to this publication will be kept in view by the Editors, who will endeavour to make it a magazine of science, plainly worded and exactly described.

The ablest exponents of science will be invited to contribute articles and letters to its pages, and more space than hitherto will be devoted to Physics and Physical Geography, and to Natural History, including Botany. The space devoted to Astronomy must be somewhat curtailed, but it will probably still remain the leading feature of the magazine.

The Editors will use their discretion in repressing in the papers accepted for publication Anglicised Latin when, as is usually the case, the same idea can be as accurately expressed in ordinary words. Reviews of new scientific books and papers read before scientific societies will be given in a popular form, with illustrations, and scientific news will as far as possible be translated into the language of ordinary life.

The publishers have purchased from Mr. Proctor's representatives a great number of unpublished articles by Mr. Proctor, which will be produced from time to time, but papers referring to politics and religion will be avoided as not coming within the field of KNOWLEDGE as originally mapped out.

The columns for chess and whist (regarded as scientific games) will be continued, and a correspondence section will be opened for full and free discussion on matters likely to be of interest to general readers.

Those who approve of the plan above sketched out and wish to see

KNOWLEDGE grow from more to more,

can help us by making the magazine known to their friends, and introducing it to clubs and institutes where it is not already subscribed for.

MR. PROCTOR'S LAST ARTICLE.

READERS of KNOWLEDGE will be interested in seeing the last article written by Mr. Proctor only a few days before he started for New York, where death overtook him. The article was written on the broad balcony of his house in Florida, close to the room where his wife was lying ill with fever, which at first was suspected to be yellow fever. During the anxious period of doubt he had given himself to reading all the medical literature at hand referring to yellow fever and plagues, and he gave the benefit of his information to the readers of the New York *Weekly Tribune*, from which we reprint the greater portion of his article. It will be seen from the reports which we give in another column that the loss of Mr. Proctor's valuable life was probably not due to yellow fever, but to the panic produced by the yellow fever scare, which caused the doctors attending him and the New York hotel proprietor to insist on his removal on a rainy and windy night when he was suffering from *Malarial Fever*.

PLAGUE AND PESTILENCE.

YELLOW FEVER, though not in reality a more destructive disease, even in the places where it is apt to prevail, than some others which are more familiar, is more suggestive of the idea of pestilence than any existent disease, and more strikingly recalls, when it appears in a fully developed form, as ten years ago in New Orleans and Memphis, the horrors of the ancient plagues. There is something in the insidious nature of its approach, its fell action in the worst cases, and the despair which seizes even from the beginning the larger number of its victims, which reminds us of what we have read respecting the plagues of Athens, of Florence, of London, in the days of old. I am told by those who witnessed the flight from Jacksonville, Florida, a short time since, when first the appearance of yellow fever in that town had been announced, that the behaviour of many of the refugees indicated absolutely panic terror, though, as it turned out, not one among the whole number had been infected by the disease, so that the risk individually run by that panic-stricken crowd while in the town from which they were flying must have been small.

It may be interesting to recall a few of the features of the great plagues and pestilences of history—if for no other reason, for this: that men may see how light even the worst infections of the kind during this century have been by comparison.

The account given by Thucydides of the plague of Athens,

twenty-three centuries ago, suggests a scene of fearful horror. The origin of the plague is noteworthy in the light of modern theories and discoveries respecting disease germs. The Spartans, having overcome the Athenians in the field, ravaged Attica while nearly all its inhabitants were closely shut up within the walls of Athens. Whether the germs of the disease had already been conveyed to Athens, or whether spreading in the air they found in the overcrowded sorrow-stricken city a favourable field for their development, cannot be learned. It was said that the plague had had its origin in Ethiopia, the region now including Abyssinia, Nubia, and the Soudan, and had travelled thence by Egypt and Asia Minor to Athens. But its rapid development in Athens would certainly seem to suggest that this plague (and probably therefore others) depended on surrounding conditions for its development.

This pestilential fever began with heat in the head and inflammation in the eyes. The tongue and throat became bloody and the breath fetid. Sneezing and heavy coughing, hiccoughs and spasms, marked the progress of the disease. Colic and intense pain supervened. The skin became red, ulcers formed here and there; and although the internal fever was intense, the skin was cold. Thirst was unquenchable, and intense pain rendered sleep impossible. The fate of the patient was usually decided by or before the seventh day, death generally closing his sufferings between the seventh and the ninth day. Few survived, and for a large proportion of those who did life was worse than death, since either they were wholly crippled or the disease left them with mind impaired and memory gone. No remedy was found for the disease, and the helplessness of the physicians caused a despondency among those who were attacked which rendered the mortality largely greater than otherwise it would probably have been. But most of those attacked were left untended; for it was found that few among the attendants on the sick escaped, so that only those of bravest and most generous minds dared the risk of nursing even those dearest to them. It was impossible, crowded as the beleaguered city was, to keep the healthy apart from the sick. Hundreds flocked around each of the public fountains to allay their raging thirst. The temples were filled with corpses, for it was impossible to get the dead conveyed to suitable places of interment.

Whereas the assurance of death should produce in healthy minds the very reverse of the idea, "Let us eat and drink, for to-morrow we die"—whether the to-morrow be figurative or literal, in times of plague and pestilence, when all men feel the probable nearness of death, and, even where most confident, are reminded of its certainty at no very distant date, the majority invariably turn to riotous living. They seek to fill what remains to them of life with all the sensual pleasures they can crowd into it. Thus as in Athens during the time of horror so graphically described by Thucydides, riot and debauchery prevailed unceasingly. Gross dissipation and tumultuous revelry went on in such sort that but for the signs of death and disease everywhere prevalent, a stranger entering the city might have imagined that it was a time of wild rejoicing over some great national triumph. Men committed crimes from which at other times the fear of the law would have deterred them; for the law had no terrors where nature threatened an earlier punishment than any legal process could inflict. As they saw the good and the bad, the openly profane and the professedly pious, stricken down impartially, they lost all belief in the control of the gods, and therefore saw no reason to deny themselves whatever pleasures they could obtain.

Thucydides says that during the plague, there died within the limits of the city of Athens, then as now but a small city, no fewer than five thousand of the soldiers, and of the other inhabitants a number too great to be reckoned.

Very striking is the contrast between the plague of Athens, affecting chiefly a single city and lasting but a short time, and the plague which extended with varying degrees of intensity from Persia to Gaul in the reign of Justinian, lasting no less than thirty years, and destroying (according to an estimate which the historian Gibbon did not consider extravagant) no fewer than a hundred millions of human beings—a number not much less than the entire population of Great Britain and the United States.

In this long-lasting and most terrible plague the features of the disease were quite unlike what had been noticed during the plague of Athens. Procopius studied it both as historian and physician. In most cases the mind was first attacked, anxious fears and saddening visions seeming to overpower the reasoning faculties. But usually a mild fever was the first sign of mischief, nothing in its earlier progress suggesting any serious danger. Before long, however, the glands beneath the ears, under the arm-pits, and in the groin swelled alarmingly, especially as these swellings were soon recognised as signs that the dreaded plague fever had indeed seized its victim. The swellings became tumours, within which a hard dark substance as large as a bean was formed. If these tumours remained hard and dry, blood poisoning followed, and on or about the fifth day from the setting in of the disease the patient died. But if the tumours softened and suppurated, the venom of the plague seemed to be discharged, and the patient was saved. Sometimes the fever accompanying the development of these tumours brought a profound lethargy on the patient, who suffered little, begging only to be let alone that he might die untortured by medicine, surgery, or even nursing. More frequently the fever brought on raging and delirium. In all cases the bodies of those who died of the plague were covered with black boils or carbuncles. All hope was given up when these appeared. Among those who recovered a considerable portion lost sight and hearing, while others remained ever afterwards speechless.

Strictly speaking the peculiarities above described are to be regarded as characteristic of the true plague—so that the so-called plague of Athens, as well as the plague which afflicted the whole Roman Empire in the reign of Aurelius, and that again of the third century, were not really plagues in the full sense of the term. It would almost seem, indeed, as though the plague of Athens was but an exceptionally malignant form of remittent fever.

The true plague is defined as a specific contagious fever accompanied by the formation of tumours, and sometimes of carbuncles. Dark spots on the skin are regarded as infallible signs of death. They are due to the effusion of blood under the skin, and precede death by only a few hours. The skin is sometimes so covered with these spots as to assume a dark livid hue after death—whence the name Black Death given to the worst form of plague.

During Justinian's plague, the idea prevailed that the disease was not contagious—an idea which if it saved the afflicted nations from a portion of the troubles accompanying the appearance of pestilence, brought in others more terrible. Doubtless the quiet disregard of danger at such seasons is desirable, so only that it does not cause the neglect of necessary precautions. But disregard of danger is a dangerous quality when it has its origin merely in ignorance. It so proved in this case. The friends and relatives of the deceased were more careful in their attentions than during most plagues, but the absence of all restraints on the communication of the disease from house to house, from city to city, and from country to country led to results the most disastrous. Procopius tells us that the

plague spread from Persia to Gaul, from the sea-coast to the interior. No island or mountain district was so sequestered but that the plague spread to it, either at its first passage across a region, or later (sometimes with even more terrible effect) in places which were supposed to have escaped. The succession of the seasons seemed to have no influence on this long-lasting pestilence. (I have named thirty years, but, according to some historians, its effects continued for more than half a century.)

The plague of Florence in the middle of the fourteenth century was remarkable, like that of Athens, for the limited area which it affected, or rather in which it wrought its most deadly effects and rose to true plague pitch. If Florence when the plague reached her had given way to despair, and taken no measures to resist the enemy, one might more readily understand the terrible intensity of the sufferings of the people. But all remedies known in those days were tried. The streets were cleaned; suspected persons were removed or prevented from entering; every measure was adopted which the wisest and most prudent of the inhabitants could suggest. Yet the plague raged in Florence as it raged nowhere else.

Tumours such as those which appeared during Justinian's plague appeared during the plague of Florence, and as in the sixth century so in the fourteenth, purple spots on the body of the diseased were regarded as sure tokens of approaching dissolution. Death came earlier, however, the sufferers usually dying on the third day. Animals as well as men were infected. Boccaccio tells us that he saw two hogs rooting among the clothes of a man who had died of the plague—"in less than an hour," he adds, "they turned round and died on the spot."

As in former plagues, the restraints of religion seemed to lose their influence. Every one, says one writer, did as he pleased. This doubtless is an exaggeration, since we have evidence that the monks and friars stood bravely to the work of religious consolation and physical help. The idea conveyed in the introductory matter of Boccaccio's "Decameron," that the occasion seemed one when men and women seemed to turn naturally from the gloom around to festivity and dissipation, even to debauchery and riot, is undoubtedly correct. What could it matter? all save a few devotees seemed to think. "If we are to die by the plague, we may as well enjoy what little of life remains to us; if we are to survive, we need not trouble ourselves with unnecessary anxieties."

When the plague was at its highest towards its close, it became the custom for the dead to be put out of doors at night that the officers appointed for the purpose might remove them in the morning. It is computed that between seventy thousand and one hundred thousand died of the plague in Tuscany alone, between March and August 1348. "Such," says Boccaccio, "was the severity of heaven."

The plague in England, described by Defoe as an eye-witness, though he was but an infant in 1665 and 1666 when it raged, though terrible was not to be compared for severity with the plague of 1346. As many died, indeed, perhaps more; but in a much larger population. It began in the autumn of 1665; but the cold winter of 1665–1666 greatly checked its ravages, and many hoped that it would altogether disappear. But with the early spring of 1666 deaths from the pestilence began to be announced, until presently it began to be recognised that the real attack had begun. The symptoms were akin to those observed during the plague of Florence, but sometimes death came even more rapidly. In July 2,000 died weekly, but by September the weekly number of deaths from the plague had risen to 8,000. The dead were buried together in certain fields, then suburban, now within London proper. There is one triangular space (not built on) between Brompton and Kensington, where large numbers were buried. Many of the dead were buried in the fields at present occupied by the houses in Golden Square; and it was noticed that during the visitation of cholera in 1849 the disease seemed more malignant in that region; but whether this was due, as some surmised, to the opening of drains communicating with the trenches in which the plague-stricken were buried in 1665 and 1666 seems open to considerable question.

In the East the plague still appears from time to time, but whatever may be the reason, it seems unable to pass thence into Europe. During the plague of 1835 in Alexandria (in which 9,000 inhabitants of that city perished), twenty-five ships, eight of which were certainly infected with plague, carried 31,000 bales of cotton to England. Yet no case of plague occurred among those employed in unloading and disinfecting the cargoes. Equally large cargoes were unloaded at Marseilles and Trieste, with the same result. Thus the disease, however communicated, is apparently never conveyed by merchandise. It would seem, in fact, to require special infection, since in 1878, the plague was for two months confined to a single village in Russia. In 1834 plague existed for eight months in Alexandria before being communicated to Damietta and Mansoorah, though no measures were taken to interrupt traffic. On the other hand, where several plague-stricken persons are together in a house or ship, a certain atmosphere of infection seems to be formed by which the disease may be transmitted.

RICHARD A. PROCTOR.

MR. PROCTOR'S DEATH.

(Reprinted from the *Ocala Banner.*)

A MEETING of physicians, representing the Boards of Health of several of the interior counties, was held in Ocala last Sunday, and among the matters discussed was that of the death of Mr. Richard A. Proctor. Every physician present ridiculed the idea of his having died of yellow fever as reported by his attending physicians and the health authorities of New York city.

The opinion was unanimous that the symptoms given by the physicians attending him, as reported in the *World*, *Herald*, and other newspapers, from the time he left his home at Oaklawn until he was sent mercilessly forth in a drenching rain to his death, plainly and unmistakably pointed to the one conclusion that the disease of which the unfortunate astronomer died was *malarial hæmorrhagic*, and not *yellow fever*.

Dr. Thomas P. Gary, the President of the combined Boards of Health of the counties present, was appointed a committee to prepare for publication in the New York newspapers the opinions as stated above, and the facts upon which they were based, which Dr. Gary did in a brief space of time, and the same was forwarded at once to the New York newspapers for publication.

The facts in Mr Proctor's case are mysterious. There has never been a case of fever in this county but one, and that was a stage-driver from Gainesville during the epidemic in 1871, and in that case the fever did not spread, the man himself recovered, and there was no alarm. People were not as panic-stricken in those days as they are now. Mr. Proctor's home, at the time of his leaving it, was fully a hundred miles from any infected district. For weeks previously he had been at home busily engaged in the prepara-

tion of his great astronomical works, and had not come in contact with any person from any infected district before leaving for New York, and on his way thither he went seventy-five miles around to avoid the infected regions. It has been ascertained that there were ninety-three passengers on the train with him, and yet among this big list of passengers no other case was developed, nor has any since developed so far as known. That strikes even those unacquainted with the disease as somewhat remarkable, to say the least. But more than that, Mr. Proctor was reported sick and vomiting the first day of his journey, and any layman knows that that is not the first indication of yellow fever, and Dr. Gary, in his report, a copy of which we are sorry was not given us, makes this plain. Mr. Proctor, if he really came in contact with the disease, must have passed through an incubating season before the microbes would have made their presence known, and vomiting, instead of being the first is one of the last manifestations of the disease.

But granting that all the yellow fever symptoms had been plainly and unmistakably developed, there is no excuse nor palliation, say these doctors, and righteously, for his removal from his hotel after having remained there for two days and a half, and at midnight in a raging storm. The mischief, if any, had already been done.

It is no wonder therefore that his friends and neighbours, and every intelligent citizen of Florida should be shocked and indignant to hear of the barbarous and unprecedented cruelties to which he was so mercilessly subjected.

When Mr. Waterman was taken sick in Tampa at the beginning of this season, notwithstanding that city passed through an epidemic of the scourge the summer before, and is directly in the yellow fever zone, he was subjected to no such treatment as that visited upon Mr. Proctor, but on the contrary, Mr. Waterman was never removed from his hotel, which was located in the heart of the city. And if he had been, the enlightened and humane physicians of that city would not have forced him out in a torrent of wind and rain and in the middle of the night. If they had, public sentiment would have driven them from the city.

The "eminent doctors" who subjected Mr. Proctor to this inhuman treatment should follow Henry Guy Carlton's advice, published in our last issue from the New York *World*, and when another suspicious case of fever is developed in New York, consult some "old turbaned New Orleans mammy," with "wrapped and kinky hair," and be guided wholly by her counsels. She would not mistake a case of *malarial hæmorrhagic fever* for *yellow fever*, and in any event would not hurry so distinguished a victim forth in a storm at night to meet his certain and almost immediate death.

The statement of Professor Jacobi, "that yellow fever is in all parts of Florida, and that there is danger of persons from any section of the State spreading the disease," was also discussed by these doctors. They positively announced, after the most diligent and rigid investigations, that in only four of the forty-five counties of Florida has a single case of yellow fever made its appearance this summer.

THE FORMATION OF CORAL REEFS.

By W. H. Wesley.

THERE are perhaps few facts more striking to the imagination than the existence of the innumerable reefs and islands of coral which bestrew our tropical seas. At the same time there are few problems in physical geography more full of difficulties than those presented by these little rings of land —often only a few yards in width, and rising but a few feet above the swell of the mightiest oceans, to which they oppose a barrier, apparently so frail yet really so stable. The discussion with regard to their formation which has taken place during recent years, and of which it is proposed to give a brief *résumé*, shows that the problem is yet by no means solved.

The principal reef building species of coral are essentially shallow water forms, living between extreme low watermark and a depth of twenty to thirty fathoms. They flourish especially where the surface temperature never sinks below 70° Fahrenheit, and where the annual range is not more than 12°. They require an abundant supply of fresh water, and are killed if sand or other sediment is deposited upon them. They cannot endure an exposure to the air for even a few hours.

Coral reefs have been divided into three classes, viz.:—

1. Fringing reefs, near a shore, from which they are separated by a narrow and shallow channel.

2. Barrier reefs, forming a more or less perfect ring round a central island, with a deeper and wider "lagoon" channel.

3. Atolls, or rings of reef without any central island. The smaller atolls are generally perfect rings, and in many of them the lagoon has been filled up, while the larger atolls have mostly open channels into the lagoon. They are sometimes mere rings of separate islets, and there are cases in which the islets forming the rim are themselves smaller atolls. The rim seldom exceeds a mile in width, and is mostly much less.

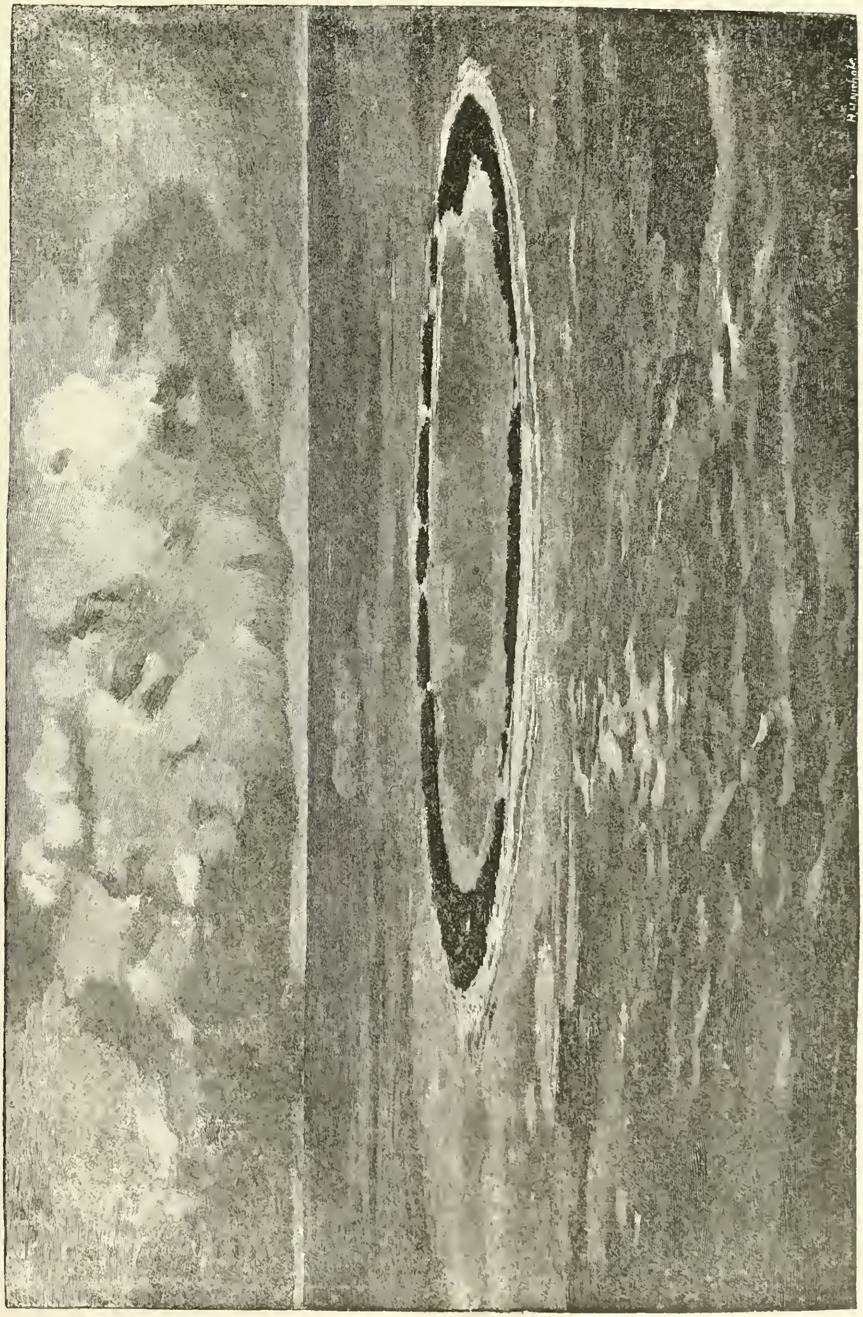
Many atolls and other reefs are always submerged, and others are only uncovered at extreme low tide. The seaward face of barrier reefs and atolls is generally very steep and the depth outside very great, while the lagoon is comparatively shallow. In some of the larger atolls, however, the lagoon is in parts as deep as 40 fathoms.

In all coral reefs it is only the extreme outer margin that is composed of living coral. The mass of the reef below water is formed of densely compacted coral, resembling ordinary limestone; but the portion above the water which (except in cases of upheaval) must have been formed by wave action alone is more porous in structure. Masses of coral, detached from the outer face, are piled on the top, forming a rampart, which becomes consolidated by the deposit of finer particles and of carbonate of lime held in solution by the water, while the living coral on the exterior face preserves the land from destruction. The rampart of coral boulders and blown coral sand is usually the highest portion of an atoll, the land sloping gradually towards the lagoon.

After the reef is thus raised above the sea-level there is a gradual accumulation of soil, in great part from the pumice stone from submarine volcanoes. The pumice being piled on the reef by the waves, in time disintegrates and forms a red clayey soil, which becomes deeper towards the lagoon shore, where the most luxuriant vegetation is found.

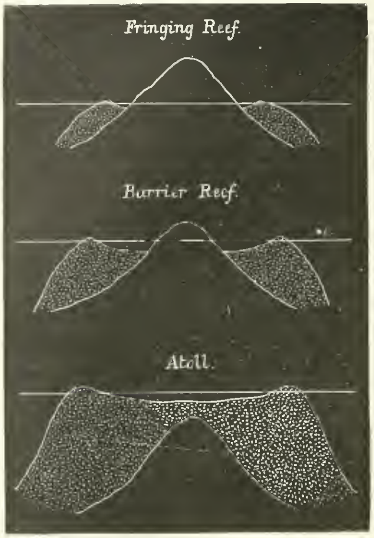
We will now consider some of the explanations of coral formations which have been given. Long ago Chamisso suggested that an atoll owes its form to the growth of coral round the margin, the deposit of débris from the outside checking growth in the interior. To account for the depth of water outside the reef—far too great for the reef building corals—it was suggested that the growths commenced round the summits of submerged volcanic cones. But it was considered improbable by Darwin that such cones could exist in sufficient numbers, and after an extended study of many islands in the Pacific and other oceans, he arrived at the following conclusions:—

Coral formations lie in a region of *subsidence*. The corals commenced to grow round the sloping shore of an island,



Bird's-eye View of Caroline Island.

and the growth, rising upwards, reached the surface and formed a fringing reef. The land subsiding, the coral continued its upward growth, so that the central island was reduced in size, the intervening channel deepened, and a barrier reef formed, which by continued subsidence became an atoll, inclosing a lagoon, without an island. The following diagram will make this clear.



In the case of submerged reefs, Darwin assumed that the subsidence had been so rapid that the coral had been carried into deep water and killed, before it had time to extend its growth in an upward direction.

Darwin's theory of subsidence was arrived at after an exhaustive study of the facts at his disposal; it was supported by a mass of evidence, and put before the world with admirable clearness and force. It was at the same time so simple and satisfactory, explaining at the same time the various forms of reefs and the great depth of water surrounding them, that it is not surprising that it met with general acceptance. But beautifully simple and complete as the theory is, it presents some serious difficulties. First among these, it involves the assumption that the whole Central Pacific, besides other large areas, has undergone enormous subsidence. Darwin, of course, fully recognised this—indeed, he was led to the belief that a Pacific continent had been submerged so completely that only a few of its mountain summits appear above the surface. But most recent deep-sea researches seem to prove the great antiquity and permanence of the large ocean basins, and this evidence must all be put aside if the Darwinian theory is to be accepted in its entirety.

Besides this general objection to the subsidence theory, many instances have been brought forward of undoubted *elevation* of the land in coral regions. Rein has shown that the Bermuda reefs have undergone elevation. Alex. Agassiz mentions* other elevated reefs in the West Indies, and with regard to Florida he says:—" All naturalists who have visited the reefs have felt the difficulty of applying Darwin's theory to the peculiar conditions existing along the straits." Semper in the Pelew Islands experienced the same difficulty, owing to the clear evidence of upheaval, and Dr. H. B. Guppy says of the Solomon Islands*:—" These upraised reef masses, whether atoll, barrier reef, or fringing reef, were formed in a region of elevation. Mr. Darwin's theory, which ascribes atolls and barrier reefs to a movement of subsidence, cannot be applied to the islands of the Solomon group." More recently it has been shown by Mr. G. C. Bourne† that there is evidence of upheaval in some of the atolls of the Chagos group in the Indian Ocean.

* " Mem. American Acad.," vol. xi.

Professor J. D. Dana, in his elaborate review of the whole question,‡ considers some of these instances of elevation, but does not think they conflict with Darwin's theory, which, while insisting upon a general subsidence, would admit of partial and local elevations.

Again, it is a difficulty on the theory that fringing reefs, barrier reefs, and atolls are merely different stages of the same formation, that all three kinds not unfrequently occur in close proximity, as in the Fiji Islands. On the hypothesis of general and very extensive submergence, we should expect that all the formations in a given area would be reduced more or less to the same condition, as in the Indian Ocean, where only atolls occur.

Besides this, all oceanic islands (other than coral islands), with scarcely an exception, are of volcanic origin, and volcanic regions are generally areas of elevation rather than of depression.

Moreover, Dr. Guppy found in the Solomon Islands the upraised reefs to be of moderate thickness only—their vertical measurement not exceeding the usual limit of the reef-building zone—while, according to Darwin's view, the vertical thickness of a barrier reef or atoll should be enormous.

But if it is shown that Darwin's theory is at any rate not of universal application, what other view can be adopted? One of the most complete alternative theories was brought forward § about eight years ago by Mr. John Murray, one of the naturalists of the *Challenger* expedition. He thus summarises his views: (1) " When coral plantations build upon submarine banks, they assume an atoll form, owing to the more abundant supply of food to the outer margins, and the removal of dead coral rock from the interior portions by currents and by the action of the carbonic acid dissolved in sea water. (2) That barrier reefs have been built out from the shore on a foundation of volcanic débris, or a talus of coral blocks, coral sediment, or pelagic shells, and the lagoon channel is formed in the same way as a lagoon."

Mr. Murray also called attention to the immense number of other organisms (calcareous algæ, foraminifera, pteropods, &c.) existing in tropical seas, which secrete carbonate of lime, and whose remains are found in great abundance on submarine banks, where they accumulate too rapidly for the sea water to have much effect in dissolving them. These deposits form banks upon which flourish numerous species of foraminifera, sponges, deep-sea corals, &c., and thus rise to a level at which reef building corals can live. Alexander Agassiz has also described the great submarine banks in the Gulf of Mexico, largely composed of the remains of minute marine organisms, the form and direction of the banks being determined by the prevailing winds and currents.

Mr. Murray shows that submarine volcanoes have been found to be far more numerous than was supposed by

* "The Solomon Islands." London: 1887.
† " Proc Roy. Soc.," vol. xliii.
‡ " American Journal of Science." Third series, Vol. xxx.
§ " Proc. Roy. Soc. Edin." Vol. x.

Darwin, so that the older view that corals built upon these cones was reasonable and probable. The cone, if rising above the surface, would soon be reduced by the action of the waves to a suitable level, or if too low, might be raised by organic deposits. Upon this the true reef-forming corals would commence to build. The outer surface being always in the most favourable position with regard to food supply, the edge would tend to reach the surface first.

Mr. Murray lays great stress upon the power of the sea-water (always containing carbonic acid, especially at great depths) in dissolving the coral which has ceased to grow, and to this cause he attributes the deepening of the central lagoon in an atoll, and the lagoon channel in a barrier reef. "Thus growing seawards on its outer face, and dissolving away in the lagoon, the whole expands after the manner of a fairy-ring, and the ribbon or reef of land can never in consequence increase beyond half or three-quarters of a mile in width" ("Journal of the Royal Institution," 1888). The greater extent of coast line in a small atoll, as compared with its contained lagoon, is probably the reason why the latter has been frequently filled up, fragments torn from the outside being carried over the rim by waves, and piled in the interior.

The power of sea-water to dissolve coral structures has been investigated, and proved by laboratory experiments, but it is still a question whether the action upon small detached pieces can be compared with that which would take place with the massive coral limestone of the reefs. There is also evidently a difficulty in understanding, as Mr. Darwin justly observes in a letter dated September 1880, and published in "Nature," November 17, 1887, how "there should be rapid dissolution of carbonate of lime at great depths [where few calcareous remains are found] and near the surface [in the deepening of lagoons] but not at intermediate depths where he [Mr. Murray] places his mountain peaks." Captain Wharton † has given several instances of entirely submerged atolls in the China seas in which the height of the rim above the lagoon is quite as great as in atolls which have reached the surface.

Murray's views with regard to the volcanic foundation of coral reefs are strongly supported by Dr. Guppy's observations.* He observes: "These upraised reef masses in the majority of the islands rest on a partially consolidated deposit, which possesses the characters of the volcanic muds that were found during the *Challenger* expedition to be at present forming around volcanic islands." Dr. Guppy infers that the deposit envelops anciently submerged volcanic peaks.

Mr. Bourne, in his interesting account of the atoll of Diego Garcia (which has a channel leading into the lagoon) in the Indian Ocean, previously quoted, shows that the reef is being worn away by tidal scour *on its lagoon side*, while the exterior is protected by the growing coral. Within the lagoon the corals only exist in patches, their growth being checked by the deposit of sediment. The Diego Garcia observations strongly support the view that coral growth proceeds most rapidly in a *horizontal* rather than in a vertical direction, as required by Darwin's theory.

Perhaps in the present state of our knowledge it will be wisest, as Dr. Guppy has suggested,† to regard as possible all the various agencies which have been suggested as producing the various forms of reef. Outside there are the directing influence of currents, the increased food supply, and the action of the breakers. Within the lagoon are the repressive influences of sediment, the boring of the numerous organisms that find a home on every reef, the solvent influence of carbonic acid, and the tidal scour. In some places also it is possible that subsidence may have played its part.

* "The Solomon Islands."

† "Nature," vol. xxxvii.

The bird's-eye view of Caroline Island has been copied from an excellent plate given in Professor Holden's Report of the 1883 Eclipse Expedition.

[We have been disappointed at the last moment in the receipt of two other woodcuts which were expected to illustrate this article.—Ed.]

HENRY DRAPER MEMORIAL.

Dr. HENRY DRAPER, of New York, who was the first to photograph a nebula, succeeded in 1872 in obtaining several photographs of the spectra of stars. His father — nearly thirty years previously — had obtained the first photograph of a human being, as well as the first photograph of the dark lines in the solar spectrum, both of these earlier photographs being taken on silver plates. At the time of Dr. Henry Draper's death in 1882, he was proposing to devote himself for several years to the photography of stellar spectra, making a catalogue of the spectra of all stars which could be photographed with the means at his disposal. His widow has raised a most suitable memorial to his memory, and that of his father, by providing funds for the establishment of a new department of Harvard College Observatory, where, under the superintendence of Professor E. C. Pickering—and with the aid of the 15-inch refractor and the 28-inch reflector used by Dr. Henry Draper, and other instruments which have since been devised by Professor Pickering—a spectroscopic catalogue of the heavens is being made, and photographs of the spectra of the brighter stars are being taken on a scale commensurate with the photographs of the solar spectrum taken only a few years ago.

Such large-scale photographs of the spectra of stars open out great possibilities in the near future of astronomy, for they will enable us to measure the velocities of stars in the line of sight (to or from the observer) with a much less percentage of error than the distances of the stars can be determined from measures of parallax. The apparent proper motion of stars (which can be determined very accurately from measures of their positions taken at intervals of many years) gives a guide to their velocities in directions at right angles to the line of sight, and with the motion in the line of sight accurately known, we shall be able to form a much juster notion of stellar distances and stellar motions than has hitherto been attained to.

THE EFFECTS OF COMPETITIVE EXAMINATIONS.

PROFESSOR DE MORGAN, who was certainly a most successful teacher if we estimate success by the number of distinguished mathematicians who were educated under him, delivered an introductory lecture, some forty years ago, on the evil effects of competitive examination, in which he stated that he considered such examinations to be among the crudities of an imperfect system, and to be as ineffectual in gaining the end either of *making* the best scholar or *showing* the best scholar, as its moral tendency is bad. The lecture was printed at the

request of some of his old pupils, and circulated amongst a good many of the thinking men of the day.

Professor Baden Powell wrote, thanking De Morgan for his lecture, and added: "I wish it could be more widely circulated among our candidates at Oxford and Cambridge. Perhaps there was something in this respect better in the system of our ancestors' disputations, in lieu of examinations. I have often wished that there was something like making a man read a dissertation on a subject of his own choosing, and then cross-examining him on his own arguments. Many would be plucked for not understanding their own meaning." Sir John Herschel wrote, "I was greatly delighted with your protest against the cramming system in your opening lecture," and Dr. Whewell wrote that he was anxious that some experiment should be made as to the possibility of getting rid of such examinations.

De Morgan did not object to examinations which were not competitive; for example, he felt that examinations by teachers to test the amount of knowledge really gained were very useful to guide them in their efforts to direct the thoughts of their pupils and interest them in the subjects taught. He believed that the most effective education commences when the pupil begins to teach himself; when he is drawn onward by interest in the subject to think for himself rather than driven by the desire for approval or money reward to store his memory with facts or words.

Since De Morgan's day we have been drifting continuously in the direction of selection by competitive examination. Large sums of public money are now distributed according to the verdict of examiners, so that school managers and schoolmasters are induced to look at the children of the poorer classes as instruments for earning Government money, and boys in the richer and middle classes are pressed, frequently to the injury of their health, to store away material likely to enable them to answer questions which may be set by examiners. The fierce goad of emulation is applied frequently before the strength and development of the boy warrants it, to urge him to reproduce rapidly the thoughts of others, in order that he may be educated at the expense of the public or of some one else than his parents.

De Morgan thought that with those young men who struggle to be highest, and who suffer in the struggle, no stimulus is needed beyond their own pleasure in learning, and that if a teacher cannot make them feel this pleasure, he does not deserve the name of teacher. Educators have to learn that the aim of education is to develop power, and not to cram knowledge, and also that the mental and moral faculties come into activity at very different times in different individuals and types. The system of selection for Government employment by competitive examination probably handicaps the Saxon as compared with Jews and other Orientals who come to maturity at an earlier period in their life history; but I will not dwell on this probability, as it is doubtful whether, with the exception of generals and heads of departments, it is for the advantage of a community that the best individuals should be taken by the Government from private callings where they are likely to have more influence upon the action and thought of the public than they would have if trammelled by official usages, and induced to rest on their oars by the knowledge that they have an assured position and a pension to fall back upon in old age.

It has frequently been said that the Duke of Wellington would, by reason of his bad spelling, never have succeeded under the modern system in entering either Woolwich or Sandhurst; but, be this as it may, it is certain that the present system of examination is not suited to select youths who possess many important qualities which are likely to prove useful in the battle of life, such as judgment, truthfulness, good moral feeling; and it would be difficult to contrive a method by which these qualities could be selected in the examination-room. But where it is necessary to select, a better choice than competitive examinations afford would probably be made if a period of probation were required, and the selecting officers had an opportunity of watching the candidate while attempting the class of work at which he would be afterwards employed.

The most serious evils brought about by the system of competitive examination are those which affect the methods of thought of teachers and of the pupils subjected to examination. What will pay in the examination-room becomes the first question, and any intellectual interests which would lead to inquiry or separate investigation are treated as luxuries which must be sternly swept on one side. This has a tendency to repress the teacher who will teach best those parts of a subject which he most enjoys, or with respect to which he has made any original investigation, or has some original thought, perhaps quite unsuited for reproduction in the examination-room; but these must be suppressed, for to follow the text-book and to reproduce statements received on authority is the habit of mind which is rewarded with success. His pupils become apt parrots. He dare not teach them to think for themselves, or they might be beaten in the race. He does not dare to introduce them to the scientific methods of inquiry by which independent advance is made. They learn to store up ideas, but not to digest them; and the habit is acquired, which will cling to them through life, of reproducing the ideas of others uncriticised and unassimilated.

It is an axiom of physiologists that the over-development of one organ tends to the atrophy of others. If the memory is forced, the powers of reasoning and imagination will be stunted. The fact that calculating boys usually lose their exceptional powers—as their general education progresses—seems to show that atrophy may almost obliterate even strongly marked faculties. But with the present system of classification by examination and the great prizes offered to the successful, it is only to be expected that boys and young men will train for them regardless of other considerations, developing the memory at the expense of all other faculties.

A. C. Ranyard.

ON SOME STRANGE FEATS OF CALCULATING BOYS.

My object in the present essay is to consider certain mental feats which seem calculated to throw light on that wonderful organ on which our consciousness, in the widest acceptation of the term, depends. In particular, they seem to indicate cerebral capabilities, uncommon at present, but which may one day be possessed by many. I do not deal here with the question, interesting though it is, whether hereafter the human race may possess greater mental energy than at present, but simply to discuss, and if possible explain, certain remarkable mental feats. I may, however, remark on this point that we must not be misled by the consideration that we do not recognise, in the few past centuries over which our survey extends, a law of continuous mental development, illustrated by the increasing greatness of the great men of successive ages. In the first place, if the average of intellectual development is steadily increasing, the men of exceptional mental power must appear to stand less conspicuously above that higher level than the great men of former ages above the lower average of their day. And,

again, the periods with which we have to deal are probably short compared with those which may be expected (when the laws of mental development come to be understood) to separate the appearance of exceptionally great minds. We carry back our thoughts to the last of the great ones in each department of mental action: and even if we do not exaggerate his relative elevation above his contemporaries, as we are apt to do, or overlook (as we are equally apt to do) the elevation of the great minds of our own time, we still forget that, in the steady rising of the mighty tide of mental progress, the waves successively flowing in above the tide-line may be separated in time by intervals of many generations, and a greater wave may be followed by several lesser ones, before another like itself, but riding on a higher sea, flows higher still above the shore-line which separates the unknown from the known.

We may begin conveniently by considering some illustrations of exceptional power in the form of mental activity least likely to deceive us—aptitude in dealing with numbers. It is well remarked by Dr. Carpenter, that this quality is so completely a product of culture that we can trace pretty clearly the history of its development. "The definite ideas which we now form of *numbers*," he proceeds, "and of the *relations of numbers*, are the products of intellectual operations based on experience. There are savages at the present time who cannot count beyond five; and even among races that have attained to a considerable proficiency in the arts of life, the range of numerical power seems extremely low. . . . The science of Arithmetic, as at present existing, may be regarded as the accumulated *product* of the intellectual ability of successive generations, each generation building up some addition to the knowledge which it has received from its predecessor. But it can scarcely be questioned by any observant person that an *aptitude* for the apprehension of numerical ideas has come to be embodied in the congenital constitution of races which have long cultivated this branch of knowledge; so that it is far easier to teach arithmetic to the child of an educated stock than it would be to a young Yanco of the Amazons, who, according to La Condamine, can count no higher than *three*, his name for which is Poettarrarorincoaroac."

As an illustration of congenital aptitude for dealing with numbers, Dr. Carpenter takes the case of Zerah Colburn: and in this I shall follow him, though, as will presently appear, I differ from him as to the significance of that case, the true interpretation of which I believe to be far simpler, but to promise much less, than that adopted by Francis Baily and quoted with approval by Carpenter.

Let us first consider the facts of this remarkable case—

Zerah Colburn was the son of an American peasant or small farmer. When he was not yet six years of age, he surprised his father by his readiness in multiplying numbers and solving other simple arithmetical problems. He was brought to London in 1812, when only eight years old, and his powers were tested by Francis Baily and other skilful mathematicians. From Carpenter's synopsis of the experiments thus made the following account is taken, technical expressions being as far as possible eliminated (or not used until explained):—

He would multiply any number less than 10 into itself successively nine times, giving the results (by actual multiplication, not from memory) faster than the person appointed to record them could set them down. He multiplied 8 into itself fifteen times, or, in technical terms, raised it to the sixteenth power; and the result, consisting of fifteen digits, was right in every figure. He raised some numbers of two figures as high as the eighth power, but found a difficulty in proceeding when the result contained a great number of figures.

So far there is nothing which cannot be explained (or which could not, if other facts did not render the explanation invalid) by assuming that the child possessed simply the power of multiplying mentally, with extreme rapidity and correctness, but in the ordinary way.* But the next test removes at once all possibility of explaining his work as done in the ordinary manner. He was asked what number, multiplied by itself, gave 106,929, and he answered 327, *before the original number could be written down.* This was wonderful. But he next achieved a more wonderful feat still, judging his work by the usual rules. He was asked what number, multiplied twice into itself, gave 268,336,125—in other words, to find the cube root of that array of digits; *with equal facility and promptness* he replied 645. Now, anyone acquainted with the process for finding the cube root—even the most convenient form of the process, as presented by Colenso and others—knows that the cube root of a number of nine digits could not be correctly determined, with pen and paper, in less than three or four minutes, if so soon. If the computor had so perfect a power of calculating mentally that he could proceed as safely as though writing down every step, and as rapidly with each line as Colburn himself in the simple processes before described, he would yet need half a minute at least to get the correct result. This, too, would imply such a power of mentally picturing sets of figures that, even if it explained Colburn's work, it would still be altogether marvellous, if not utterly inexplicable. We know, however, that Colburn was not following ordinary rules, but a method peculiar to himself. In point of fact, he was so entirely ignorant of the usual modes of procedure, that he could not perform on paper a simple sum in multiplication or division.

Let us proceed to further instances of his remarkable power of calculation.

On being asked how many minutes there are in forty-eight years, he answered, before the question could be written down, 25,228,800; which is correct, if the extra days for leap years are left out of account. He immediately after gave the correct number of seconds.

We come next, however, to results which appear much more surprising to the mathematician than any of the above, because they relate to questions for which mathematicians have not been able to provide any systematic method of procedure whatever. He was asked to name two numbers which, multiplied together, would give the number 247,483, and he immediately named 941 and 263, which are the only two numbers satisfying the condition. The same problem being set with respect to the number 171,395, he named the following pairs of numbers: 5 and 34,279; 7 and 24,485; 59 and 2,905; 83 and 2,065; 35 and 4,897; 295 and 581; and, lastly, 413 and 415. (I presume, as Mr. Baily gives the pairs in this order, that they were so announced by Colburn. The point is of some importance in considering the explanation of the boy's mental procedure.) The next feat was a wonderful one. He was asked to name a number which will divide 36,083 exactly, and he immediately replied that there is no such number; in other words, he recognised this number as what is called a *prime* number, or a number only divisible by itself and by unity, just as readily and quickly as most people would recognise 17, 19, or 23 as such a number, and a great deal more quickly than probably nine persons out of ten would recognise 53 or 59 as such.

* The account does not say whether he gave the figures successively from right to left or from left to right. If he began at the left, ordinary multiplication would not explain his success; for no one, however skilful, could multiply a number of thirteen or fourteen figures by a number of one figure so rapidly as to begin at once to name the left-hand digits.

Now, if a mathematician were set such a problem, he would have no other resource than to deal with it by direct trial. Of course he would not try every number from 1 upwards to 36,083. He would know that, if the number can be divided at all, it must be divisible by a number less than 190: for any greater divisor would go, exactly, some smaller number of times into 36,083; and that smaller number would itself be a divisor. He would see that the number is not even, and therefore cannot be divided by 2, 4, 6, or any even number. The number is not divisible by 3; for, according to a well-known rule, if it were, the sum of its digits would be so divisible; therefore he would dismiss 3, 9, 15, and all numbers divisible by 3 not already dismissed. So with 5 (for the number does not end with a 5); so with 7, by trial: 11, 13, 17, and so on. But he would have to try many numbers of two and three figures by actual division before he had completed his proof that 36,083 has no divisors. Probably (for I must confess I have not tried) he would require about a quarter of an hour of calculation before he could be confident that 36,083 is a prime number. Here however was a child, eight years old, who, to all appearance, completed the work immediately the number was proposed!

The next feat was of the same nature, but very much more difficult; indeed, it taxed the young calculator's powers more than any other feat he accomplished. Fermat, a mathematician who gave great attention to the theory of numbers, had been led, by reasoning which need not here be considered, to the conclusion that if the number 2 be multiplied into itself 31 times (that is, raised to the thirty-second power), and 1 added, the result will be a prime number. The resulting number is 4,294,967,297. The celebrated mathematician Euler succeeded, however, after a great deal of labour (and, if the truth must be told, after a great waste of time), in showing that this number is divisible by 641. The number was submitted to Zerah Colburn, who was of course not informed of Euler's prior dealings with the problem, and, *after the lapse of some weeks*, the child-calculator discovered the result which the veteran Swiss mathematician had achieved with much greater labour.

Before proceeding to inquire how Colburn achieved these wonders, we must consider what was learned about his processes. He was not very communicative—doubtless because the faculty he possessed was not accompanied by commensurate clearness of ideas in other matters. In fact, we might as reasonably expect to find a child of eight years competent to explain processes of calculating, however easily effected, as to find him able to explain how he breathed or spoke. One answer which he made to a mathematician who pressed him more than others to describe his method was clever, though the mathematician was certainly not to be ridiculed for trying to get the true explanation of Colburn's seemingly mysterious powers—"God," said the child, "put these things into my head, and I cannot put them into yours."

Some things, however, he explained as far as he could. He did not seem able to multiply together at once two numbers which *both* contained many figures. He would decompose one or other into its factors, and work with these separately. For instance, being asked to multiply 4,395 by itself, he treated 4,395 as the product of 293 and 15, first multiplying 293 by itself, and then multiplying the product twice by 15. On being asked to multiply 999,999 by itself, he treated it, in like manner, as the product of 37,037 and 27, getting the correct result. In this case probably a mathematician would have got the start of him, by treating 999,999 as a million less one, whence, by a well-known rule, its square is a million millions and one, less two millions, or 999,998,000,001. "On being interrogated," proceeds the account, "as to the method by which he obtained these results, the boy constantly declared that he did not know *how* the answers came into his mind. In the act of multiplying two numbers together, and in the raising of powers, it was evident (alike from the facts just stated and from the motion of his lips) that *some* operation was going forward in his mind, yet the operation could not, from the readiness with which the answers were furnished, have been at all allied to the usual modes of procedure."

Baily, after discussing the remarkable feats of Zerah Colburn, expressed the opinion that they indicate the existence of properties of numbers, as yet undiscovered, somewhat analogous to those on which the system of logarithms is based. "And if," says Carpenter (quoting Baily), "as Zerah grew older, he had become able to make known to others the methods by which his results were obtained, a real advance in knowledge might have been looked for. But it seems to have been the case with him, as with George Bidder and other 'calculating boys,' that with the *general* culture of the mind this *special* power faded away."

With all respect for a mathematician so competent to judge on such matters as Francis Baily, I must say his explanation seems to me altogether insufficient. So far from the properties of logarithms illustrating the feats of Zerah Colburn, they illustrate the power of mathematical development in precisely the opposite direction. The system of logarithms enabled the calculator to obtain results more quickly than of old, *not* by the *more* active exercise of his own powers of calculation, but by employing results accumulated by the labours of others. Its great advantage, and the quality which causes every mathematician to be grateful to the memory of Napier of Merchiston, resides in the fact that, by taking advantage of a well-known property of numbers, tables of moderate dimensions serve a great number of purposes which by any ordinary plan of tabulation would require several volumes of great size. If it were possible for a calculator to use as readily a set of tables equal in bulk to five volumes of the "London Directory" as he now uses a book of logarithms, and if such volumes could be as easily and as cheaply produced, tables much more labour-saving than the books of logarithms could be constructed. But of course such sets of volumes would be practically useless if they could be produced, and it would be impossible either to find calculators to form the tables or printers and publishers to bring them out. Now, of all processes by which mathematical calculation can be carried out, no two can be more unlike than mental arithmetic on the one hand, and the use of tables, of whatever kind, on the other. Napier invented his system to reduce as far as possible the mental effort in calculation, making the calculator employ results collected by others; young Colburn's success depended on mental readiness, and he was so far from using the results obtained by others, that he did not even know the ordinary methods of arithmetic. A man of Napier's way of thinking would be the last to trust to mental calculation; whereas, if Colburn had retained his skill until he had acquired power to explain his method, he would have been the last to think of such a help to calculation as a table of logarithms. Napier strongly urged the advantage of aids to calculation; Colburn would scarcely have been able to imagine their necessity.

Nor is it at all likely—we could even say it is not possible—that properties of numbers exist through the knowledge of which what Colburn did could be commonly done. The mathematicians who have dealt with theory of numbers have been too numerous and too skilful, and have worked too diligently in their field of research, to overlook such properties, if they existed. Besides, it is scarcely reason-

able to suppose that a child who had but lately learned the nature of numbers, and was altogether unacquainted with the ordinary properties, should have intuitively recognised abstruser properties. A more natural explanation must surely exist, if we consider the matter attentively.

It happens that I am able, from my own experience, to advance an explanation which accords well with the facts, and especially with the circumstance that calculating boys usually lose their exceptional power of rapid reckoning when they are instructed in and taught to practise the ordinary methods; for I used formerly to possess, though in a slight degree only, a power of finding divisors, products, and so on, which—*unlike ordinary skill in calculation*—required only to be expanded to effect what Colburn effected. It was, in point of fact, simply the power of picturing a number (not the written number, but so many "things"), and changes in the number, corresponding to division or multiplication as the case might be. Thus the number 24 would be presented as two columns of dots each containing ten, and one column containing four on the right of the columns of ten. If this number were to be multiplied by three, all that was necessary was to picture three sets of dots like that just described; then to conceive the imperfect columns brought together on the right, giving six columns of ten and three columns each of four dots; and these three gave at once (by heaping them up properly) another column of ten with two over: in all seven columns of ten and one column of two—that is, seventy-two. This takes long in writing, but, as pictured in the mind's eye, the three sets representing 24 formed themselves into the single set representing 72 in the twinkling of an eye (if the mind's eye can be imagined twinkling). The process for division was not exactly the reverse of that for multiplication. Thus, 72 being pictured as seven columns of ten and one of two, to divide it by 3, the first six columns of ten were pictured as giving twenty sets of three horizontal dots; the next column of ten gave three vertical triplets, counted from the top; and then the remaining dot at the bottom, with the other two in the imperfect column gave another triplet, or twenty-four triplets in all. These triplets could all be *seen* as it were; and the only mental calculation, properly so called, consisted in counting them, which of course was easy, twenty of them being as it were already numbered.

R. A. Proctor.

(*To be continued.*)

DANGER FROM LIGHTNING.

THERE are persons not otherwise wanting in courage who experience an oppressive sense of terror when electrical phenomena are in progress. The Emperor Augustus used to suffer the most distressing emotions during a thunderstorm, and he was in the habit of retiring to a low vaulted chamber underground, under the mistaken notion that lightning never penetrates far below the earth's surface. Major Vokes, the Irish police officer—a man whose daring was proverbial—used to be prostrated by terror during a thunderstorm. We cannot doubt that, in these instances, nervous effects are produced which are wholly distinct from the fear engendered by the simple consciousness of danger.

We have said that the danger is small when a thunderstorm is in progress. If we consider the number of persons exposed during a year, in England, to the effects of lightning-storms raging in their immediate neighbourhood, and compare with that number the small number of recorded deaths, we shall see that the *probability* of being struck by lightning is very small indeed. The danger we are exposed to in travelling along the most carefully regulated railway is many times greater than that to which, under ordinary circumstances, we are exposed when a thunderstorm is raging around us. Yet, in cases of this sort, men do not reason according to the doctrine of chances—nor, indeed, is it desirable that they should. There are measures of precaution which, small though the danger may be, it is well to adopt. In a railway carriage, it would be foolish to let the mind dwell upon the danger to which we are in reality exposed, since we can do nothing towards diminishing it. But it would be as unreasonable to neglect precautions in the presence of a heavy thunderstorm, merely because the danger of being struck is small, as it would be to neglect the rules which regulate powder-stores, merely because the instances in which fires have been caused by carrying cigar-lights in the coat-pocket, or by wearing iron on the sole of the boot, are few and far between.

We have mentioned one precautionary measure adopted by the ancients. The notion that lightning does not penetrate the earth to any considerable depth was in ancient times a widespread one. It is still prevalent in China and Japan. The emperors of Japan, according to Kæmpfer, retire during thunderstorms into a grotto, over which a cistern of water has been placed. The water may be designed to extinguish fire produced by the lightning; but more probably it is intended as an additional protection from electrical effects. Water is so excellent a conductor of electricity that, under certain circumstances, a sheet of water affords almost complete protection to whatever may be below; but this does not prevent fish from being killed by lightning, as Arago has pointed out. In the year 1670, lightning fell on the lake of Zirknitz, and killed all the fish in it, so that the inhabitants of the neighbourhood were enabled to fill twenty-eight carts with the dead fish found floating on the surface of the lake. That mere depth is no protection is well shown by the fact of those singular vitreous tubes called fulgurites, which are known to be caused by the action of lightning, often penetrating the ground to a depth of 30 or 40 feet. And instances have been known in which lightning has ascended from the ground to the storm-cloud, instead of following the reverse course. From what depth these ascending lightnings spring it is impossible to say.

Still, we can scarcely doubt that a place underground, or near the ground, is somewhat safer than a place several storeys above the ground floor.

Another remarkable opinion of the ancients was the belief that the skins of seals or of snakes afford protection against lightning. The Emperor Augustus, before mentioned, used to wear seal-skin dresses, under the impression that he derived safety from them. Seal-skin tents were also used by the Romans as a refuge for timid persons during severe thunderstorms. In the Cevennes, Arago tells us, the shepherds are still in the habit of collecting the cast-off skins of snakes. They twist them round their hats, under the belief that they thereby secure themselves against the effects of lightning.

Whether there is any real ground for this belief in the protecting effects due to seal-skins and snake-skins is not known; but there can be no doubt that the material and colour of clothing are not without their importance. When the church of Châteauneuf-les-Moutiers was struck by lightning during divine service, two of the officiating priests were severely injured, while a third escaped—who alone wore vestments ornamented with silk. In the same explosion nine persons were killed, and upwards of eighty injured. But it is noteworthy that several dogs were

present in the church, *all of which were killed.* It has also been observed that dark-coloured animals are more liable to be struck (other circumstances being the same) than the light-coloured. Nay, more; dappled and piebald animals have been struck; and it has been noticed that after the stroke, the hair on the lighter parts has come off at the slightest touch, while the hair on the darker parts has not been affected at all. It seems probable, therefore, that silk and felt clothing, and thick black cloth, afford a sort of protection, though not a very trustworthy one, to those who wear them.

The notion has long been prevalent that metallic articles should not be worn during a thunderstorm. There can be no doubt that large metallic masses, on or near the person, attract danger. Arago cites a very noteworthy instance of this. On July 21, 1819, while a thunderstorm was in progress, there were assembled twenty prisoners in the great hall of Biberach Gaol. Amongst them stood their chief, who had been condemned to death, and was chained by the waist. A heavy stroke of lightning fell on the prison, and the chief was killed, while his companions escaped.

It is not quite so clear that small metallic articles are sources of danger. The fact that when persons have been struck, the metallic portions of their attire have been in every case affected by the lightning, affords only a presumption on this point, since it does not follow that these metallic articles have actually attracted the lightning-stroke. Instances in which a metallic object has been struck, while the wearer has escaped, are more to the point, though some will be apt to recognise here a protecting agency rather than the reverse. It is related by Kundmann that a stroke of lightning once struck and *fused* a brass bodkin worn by a young girl to fasten her hair, and that she was not even burned. A lady (Arago tells us) had a bracelet fused from her wrist without suffering any injury. And we frequently see in the newspapers accounts of similar escapes. If it is conceded that in these instances the metal has attracted the lightning, it will, of course, be abundantly clear that it is preferable to remove from the person all metallic objects, such as watches, chains, bracelets, and rings, when a thunderstorm is in progress. If, on the other hand, it is thought that the lightning, which would in any case have fallen towards a person, has been attracted by the metal he has worn, so as to leave him uninjured, the contrary view must be adopted. Mr. Brydone considers that a thin chain attached in the manner of a conductor to some metallic article of attire, would serve in this way as an efficient protection. Our own opinion is, that, in general, metallic articles belonging to the attire are not likely to have any noteworthy influence, but that such influence as they do exert is unfavourable to safety. We may agree with Arago, however, that "it is hardly worth while to regard the amount of increased danger occasioned by a watch, a buckle, a chain, pieces of money, wires, pins, or other pieces of metal employed in men's or women's apparel."

Franklin recommends persons who are in houses not protected by lightning-conductors, to avoid the neighbourhood of the fireplace; for the soot within the chimneys form a good conductor of electricity, and lightning has frequently been known to enter a house by the chimney. He also recommends that we should avoid metals, gildings, and mirrors. The safest place, he tells us, is in the middle of a room, unless a chandelier be suspended there.

His next rule is not a very useful one. He recommends that we should avoid contact with the walls or the floor, and points out how this is to be done. We may place ourselves in a hammock suspended by silken cords; or, in the not unlikely absence of such a hammock, we should place ourselves on glass or pitch. Failing these, we may adopt the plan of placing ourselves on several mattresses heaped up in the centre of the room. We do not think that such precautions as these are likely to be commonly adopted during a thunderstorm, nor does it seem necessary or desirable that they should be. We have not even the assurance that they greatly diminish the danger. A stroke of lightning which fell on the barracks of St. Maurice at Lille, in 1838, pierced the mattresses of two beds through and through.

That glass is a protection from lightning is an opinion which has been, and perhaps still is, very prevalent; yet there have been many instances tending to prove the contrary. In September 1780, Mr. Adair was struck to the ground by lightning, which killed two servants who were standing near him. The glass of the window had not only offered no effective resistance to the lightning, but had been completely pulverised by it, the framework of the window remaining uninjured. Again, in September 1772, lightning pierced through a pane of glass in a window on the ground floor of a house in Padua, "making a hole as round as if drilled with an auger."

It seems to have been established that if a thunderstorm is in progress, a building is in more danger of being struck when many persons are crowded within it, than when few are present. This points to the danger of the course sometimes followed by the inmates of a house during a thunderstorm. They appear to think that there is safety in society, and crowd into one or two rooms, that they may try, by conversation and mutual encouragement, to shake off the feeling of danger which oppresses them. They are in reality adding, and that sensibly, to any danger there may be. "There is," says Arago, "a source of danger where large assemblies of men or animals are present, in the ascending currents of vapour caused by the perspiration." Like water, moist air is a good conductor of electricity, and lightning is attracted in the same way—though not, of course, to the same extent, by an ascending column of vapour, as by a regular lightning-conductor. It is on this account, probably, that flocks of sheep are so frequently struck, and so many of them killed by a single stroke. Barns containing grain which has been housed before it is quite dry are more commonly struck by lightning than other buildings, the ascending column of moist air being probably the attracting cause in this case, as in the former. When we are overtaken by a thunderstorm in the open air, precaution is more necessary than within a house. It is well to know, especially when no shelter is near, what is the most prudent course to adopt.

It has been stated that there is danger in running against the wind during a thunderstorm, and that it is better to walk with than against the wind. One should even, it is said, if the wind is very high, run with the wind. The *rationale* of these rules seems to be this: a current of air is produced when we run against the wind, the air on the side turned *from* the wind being rarer than the surrounding air. A man so running "leaves a space behind him in which the air is, comparatively speaking, rarefied, and lightning would be more likely to seek such a space for its track than a region in which the air is more dense." An instance is recorded in which, during a gale, lightning actually left a conductor which passed from the mast of a ship to her windward side, in order to traverse the space of rarefied air on the ship's larboard side! But the explanation is more than doubtful, though the fact may be well attested.

It is quite certain that trees are very likely to be struck by lightning, and, therefore, that it is an exceedingly dangerous thing to stand under trees in a storm. No consideration of shelter should induce any one to adopt so dangerous a course. The danger, in fact, is very much greater when heavy rain is falling, since the tree, loaded with moisture,

becomes an efficient lightning-conductor. For similar reasons, it is dangerous to seek the shelter of a lofty building (not protected by a lightning-conductor) in a thunderstorm. One of the most terrible catastrophes known in the history of thunderstorms occurred to a crowd of persons who stood in the porch of a village church waiting till a thunder-shower should have passed away.

In the open air, when a heavy thunderstorm is progressing, and no shelter near, the best course is to place one's self at a moderate distance from some tall trees. Franklin considered a distance of about 15 or 20 feet the best. Henley also considered 5 or 6 yards a suitable distance in the case of a single tree. But when the tree is lofty, a somewhat greater distance is preferable.

The reader need hardly be reminded, perhaps, that the necessity for taking these precautions only exists when the storm is really raging close at hand. When the interval which elapses between the lightning-flash and the thunder-peal is such as to show that the storm is in reality many miles away, it is altogether unnecessary to take precautions of any sort, however brilliant the flash may be, or however loud the peal. It must be noticed, however, that a storm often travels very rapidly. If the interval of time between the lightning and the thunder is observed to diminish markedly, so that the storm is found to be rapidly approaching the observer's station, the same precautions should at once be taken as though the storm were raging immediately around him. So soon as the interval begins to grow longer, it may be inferred that the storm has passed its point of nearest approach, and is receding. But the laws according to which thunderstorms travel are as yet very little understood; and it is unsafe to assume that because the interval between flash and peal has begun to increase after having diminished, the storm is therefore *certainly* passing away. It must be in the experience of all who have noted the circumstances of thunderstorms, that when a storm is in the neighbourhood of the observer, the interval between the flash and the thunder-peal will often increase and diminish alternately several times in succession. It is only when the interval has become considerable, that the danger may be assumed to have passed away.

GEOLOGY IN LONDON.

By W. Jerome Harrison, F.G.S.

HAVING described the various museums and collections of specimens which are likely to assist the student of geology in London, we may now proceed to consider where he may obtain the active teaching which shall give life to the fossils, and enable the stones to preach their own sermons. First, however, we may mention that since the appearance of our former article the extensive collections formed by the late Henry Christy to illustrate the life of prehistoric man, by comparing his weapons, tools, &c. with those of modern savage tribes, have been arranged in the galleries of the British Museum, Great Russell Street, and are now accessible to the public.

There is another point connected with the first part of our subject to which we may perhaps allude here. The streets and buildings of London are in themselves a geological museum to those who consider them with an observing eye. The pavements are largely formed of flat slabs of sandstone from the carboniferous rocks of the West Riding of Yorkshire—York stone, as the builders call it. Where the horse road is paved with "setts" (cubes of stone about six inches along each edge) these can be seen—after a good shower of rain—to be either a compact black stone, in which case they are a basalt (probably from the Rowley Hills, near Dudley), or a speckled stone formed of crystals of felspar, quartz, mica, &c., constituting a granite or a syenite. The hills of Charnwood Forest, in Leicestershire, yield enormous quantities of stone for this purpose; in the chief quarry at Mountsorrel, which is very visible from the Midland Railway between Leicester and Loughborough, about 700 men find regular employment. The Channel Islands—especially Guernsey—and Cornwall also yield excellent granite, mostly of a whitish colour, but as the stone from these localities can be obtained in large blocks free from joints, it is more valuable for building purposes. The Thames embankment is chiefly of Guernsey granite. As to the materials of which London houses are built, brick is of course the cheapest, because the necessary clay is furnished by the "London Clay," a bed of which, several hundred feet in thickness, encircles the metropolis. The red colour of a common brick is due to a small percentage of peroxide of iron. Limestone—white or yellowish-white in colour—is largely supplied from the quarries of oolitic limestone round Bath in Somersetshire and Portland in Dorsetshire. Westminster Hall and the Houses of Parliament are built of magnesian limestone (*Permian*) from Nottinghamshire. It is easy to distinguish a limestone by the way in which it effervesces when an acid—vinegar, for example, though dilute hydrochloric acid is preferable—is poured upon it. The effervescence is due to the escape of carbonic acid gas. The sandstones, also largely employed for public buildings, come mainly from the millstone grit (*Carboniferous series*) of the north and west of England. The roofing-slates come chiefly from the great quarries in the *Cambrian Rocks* round Snowdon; although the quarries at Swithland and Groby in Charnwood Forest (Leicestershire) have of late years yielded a limited supply. The St. Pancras Hotel is roofed with Charnwood slates.

INSTITUTIONS WHERE GEOLOGY IS TAUGHT.

Until quite lately the Jermyn Street Geological Museum had associated with it a Government Institution known as the "Royal School of Mines," first established in 1851. But lack of accommodation caused a gradual transfer of the students to the "Science Schools" at South Kensington—a large red brick and terra-cotta building in Exhibition Road, facing the Exhibition entrance. The change was completed in 1882, and the Institution is now known as "The Normal College of Science and Royal School of Mines." The teaching of "mining" proper is, however, still continued at Jermyn Street, by Professor Warington W. Smyth, since the splendid collections of models, ores, &c., there accumulated offer special advantages.

At South Kensington the geological class-rooms are at the top of the building, and in the work here Professor J. W. Judd is assisted by Mr. Cole as demonstrator, and Mr. Rutley as lecturer on mineralogy. Professor Judd's name is well known to every geologist. His work on the Geological Survey was excellently done, and his travels on the continent enabled him to write a book on "Volcanoes," which at once became an authority. He is now President of the Geological Society. For those who desire to take the Associateship of the School of Mines a three years' course is provided at South Kensington, and there is no better training in science given anywhere; but occasional students are also admitted to the geological class on payment of 4*l.* for the lectures, and 8*l.* for the laboratory work for the session.

Full particulars are given in a prospectus which can be obtained by application to the Registrar.

Science and Art Department Classes.—There are about twelve classes in geology held in London in connection with the Science and Art Department. Of these we may name the Polytechnic, Regent Street; Birkbeck School, Cambridge Road, Bethnal Green; the Working Men's College, 45, Great Ormond Street, Bloomsbury; the Birkbeck Institute, Chancery Lane; Onslow College, 183, King's Road, Chelsea; St. Thomas' Charterhouse, Goswell Road; City of London College, Moorfields, &c. These classes usually meet one evening per week from September to May. The fees are generally so moderate as to be nominal, but the students are expected to sit at the annual Government examination in May, as grants are paid by the Department for those who pass. These classes are spread all over the United Kingdom, and those who wish for details should send six stamps to the Secretary, South Kensington, for the "Directory" of the Science and Art Department.

University College, Gower Street.—Professor Bonney is here the "Yates-Goldsmid Professor" of Geology and Mineralogy. Professor Bonney stands in the very front rank of British geologists. His special line of work is the microscopical investigation of igneous and metamorphic rocks. The course in geology extends from January to June, and includes lectures, practical work on the rocks and fossils in the College Museum, &c. The fee is four guineas.

King's College, in the Strand, owns Professor Wiltshire as its Professor of Geology. Mr. Wiltshire's *forte* is palæontology, and as Secretary of the Palæontographical Society (established for the purpose of figuring and describing all the British fossils) he has brought out a series of magnificent volumes at a comparatively small expense.

Detailed prospectuses are issued by the authorities of both University and King's Colleges.

SCIENTIFIC SOCIETIES FOUNDED FOR THE STUDY OF GEOLOGY.

The *Geological Society of London* is one of the great scientific societies for whom our Government provides splendid accommodation in Burlington House, Piccadilly. Although the society is styled as "of London," its members are recruited from every part of the British Empire. Ever since its foundation in 1807 the society has steadily increased in numbers and influence, and the letters F.G.S. appended to a man's name have always been accepted as a guarantee of *some* knowledge of geology on the part of the possessor. Candidates for membership must be nominated by three fellows of the society, to one at least of whom they must be personally known. The names are read out at three meetings of the society, and a ballot is then taken. The entrance fee is six guineas, and the annual subscription two guineas. The present number of members is about 1,450. The meetings are held at Burlington House at eight P.M. on the first and third Wednesdays of each month from November to June inclusive. All our great geologists have held office in connection with the Geological Society; and the present President, Professor Judd, is a worthy successor of the great men who have preceded him. The society has an admirable library and museum, which are open to fellows and their friends from ten to five daily. The "Quarterly Journal" of the Geological Society contains the papers read before the society, and is a well edited and illustrated periodical. It is sold to non-members at five shillings per number. Mr. W. S. Dallas, Burlington House, is the able and courteous Assistant-Secretary, Librarian, and Curator.

The Geologists' Association was founded in 1869. Its object is, in addition to the reading of papers on geological subjects, to instruct its members by Saturday afternoon excursions to museums and places of geological interest near London. At holiday times places more distant are visited, and in this way the association has covered most of England, and has even crossed the Channel to examine the rocks of France and Belgium. The head-quarters are at University College, Gower Street, where there is a good library of geological books at the disposal of the members. The entrance fee is ten shillings, and the annual subscription is of the same amount. The number of members is nearly 500, and the Secretary is Dr. Foulerton, F.G.S., 44 Pembridge Villas, W. The "Proceedings" of the society are published quarterly, and are sold to non-members at 1*s.* 6*d.* each. This is a society which has done, and is doing, excellent work. The leaders of the excursions are always geologists of high standing, while the curators of the museums and other places visited seem always anxious to further the objects of the association.

Perhaps, in conclusion, a word may be said on the text-books of geology suitable for the student. For young people—and indeed for oldsters too—there is no better introduction to geology than Professor A. Geikie's two little "Primers" of geology and physical geography, published by Macmillan. These should be followed by Professor Huxley's "Physiography," in which a most admirable and detailed account of the physical features of the Thames Valley is given. Then Professor A. Geikie's larger "Class-book of Geology" may be mastered; and the same author's great "Manual of Geology" with Lyell's "Student's Elements" and Professor A. H. Green's "Physical Geology" will complete our list.

Those who desire to study the geology of any particular spot in England or Wales will find my "Geology of the Counties," published by Kelly & Co., useful as a book of reference. The special books and papers treating of the strata under and around London will be mentioned in my next article.

STAR-BORN METEORS.

By RICHARD A. PROCTOR.

WHEN Copernicus had shown the sun to be the true centre of the planetary motions, Tycho Brahe pointed out that, if this is so, a result of the most startling kind must be accepted, a result which he for one rejected altogether. His own observations, which eventually proved the very basis of the new theory, he bequeathed to the world with the express injunction that they should not be used in its support. He reasoned that if the earth really moves around the sun, the unchanging aspect of the constellations cannot but mean that the stars are thousands of times farther from us than the sun! It is not merely, he argued, that the eye sees no change; the great quadrant of Uranienberg, by which I could detect a displacement of less than a minute of arc, shows no displacement at all in the position of any star as the earth sweeps round her immense orbit. If this preposterous theory—this unholy theory—is true, we should have to set the stars at such distances that each would be a sun—which is altogether inadmissible.

We know how even the vast stellar distances thus indicated were found to be as nothing compared with the distances indicated when more exact instruments were made. The estimated distance of the sun has been increased about thirty-fold; the heavenly arcs measurable by modern instruments have been reduced a hundred-fold. Each change

has thrown the stars farther into space in corresponding proportion, so that, instead of the stars' distances being measured by thousands of millions of miles, they must be measured by millions of millions, perhaps by hundreds or thousands of millions of millions of miles. Yet now the doubts of Tycho Brahe have entirely vanished. We *know* that what he rejected as impossible is the simple truth. Nay, the discoveries made with the telescope show that what he held so marvellous is but the merest nothing compared with the real truth. For, far beyond the stars of which Tycho Brahe knew, exceeding them millions of times in number, lie the stars revealed by the telescope, and these also, like their brighter and (on the whole) nearer compeers, show no measurable displacement as the earth circles round her mighty orbit, a hundred and eighty-five millions of miles in span.

A discovery recently made leads to a result almost as amazing as that rejected by Tycho Brahe; nay, so amazing that it has long led astronomers to reject, as he did, what would have seemed fairly demonstrated were it not for the incredible nature of the conclusion which must be accepted along with it. In this case, as four centuries ago, it is the earth's orbital motion which is in question. I might, indeed, almost say that the earth's orbital motion would be rendered doubtful by the new discovery, if the accumulated proofs of the earth's revolution around the sun were not overwhelming. Again it has been shown that the earth's motion around the sun, vast though her orbit is, and tremendous the velocity with which she moves, produces no appreciable effect where one would expect its effect to be most marked.

Meteoric astronomy has latterly been fruitful in remarkable discoveries. Within the last quarter of a century, the position of meteors in the universe has been made more and more remarkable by a series of discoveries of singular interest. The views of Prof. Olmstead, of Hartford, Connecticut, which had been overlooked save by a few of the bolder thinkers when first advanced, have not only been established, but details which he could not indicate have been determined, and meteor systems shown to be far more remarkable even than he had imagined. They have been recognised as crossing our own earth's track in hundreds, while within the solar system astronomy has learned to recognise millions of millions, not of meteors, but of meteor systems, each containing trillions of trillions of individual meteors within its limits. And now peculiarities have been recognised which compel us to raise our conceptions of the range and number of these systems far higher, to recognise them as including not only interplanetary systems countless in number, and as we had thought amazing in range and extent, but as extending into the interstellar depths, across those seemingly illimitable spaces which separate our sun from his fellow-suns among the stars. Moreover, we recognise that even our ideas respecting the origin of these bodies must be widened, that theories which had been regarded as reasonable and probable must be rejected, and other theories which had seemed too amazing to be thought of, must be entertained.

Let me here briefly recapitulate the evidence on which accepted theories (here I speak of theories really accepted and demonstrated) had been based, in order that the bearing of the new discovery may be clearly recognised.

It had been shown by Olmstead that because showers of falling stars, of the same character, recur on particular days (or nights) of the year, therefore they must be due to the earth's passage through flights or streams of meteors crossing her orbit at certain definite points; for a day in the year is the time when the earth in her motion around the sun reaches a particular part of her orbit. He had shown further that the behaviour of meteors belonging to these showers corresponds with this theory, or rather with this demonstrated fact; for they are invariably found to radiate from a particular point, or small region, of the heavens. That is to say, if the tracks of the meteors seen during any great display are marked down on a celestial globe, or on a map so planned that the paths of meteors, however long, would be represented by straight lines, these tracks, carried backwards in great circles on the globe, or in straight lines on the map, all pass through or very near a certain fixed point on the celestial sphere. It matters not where the observer may be who watches the display—in England, or in America, or in Asia, Africa, or Australia—the same law holds: except for straggling meteors which belong to other systems, every meteor of the display has a track which, carried backwards, is found to extend from the proper "radiant point" for that system, the radiant being unchanging among the stars. Nor does it matter how long the display may last, or how far the radiant may be shifted with respect to the horizon; among the stars it always has the same position. Olmstead showed the meaning of this, though indeed the meaning should be obvious. A series of parallel lines, or lines directed to the same point in remote space, always appear to radiate from a point, if they are complete; and if parts of them only are seen (as is of course the case with meteor tracks), these parts always have *directions* radiating from that point. Hence meteor paths in our atmosphere are all parallel: and as the point from which they radiate is unchanging in the star-sphere, the direction of parallelism does not change as the earth rotates, and the paths must therefore have been parallel before the meteors entered the air. Thus, the meteors are bodies travelling with velocities so great that neither the motion of the observer round the earth's axis, nor the effect of the earth's attraction on the meteors as they near her, has any effect in altering either the apparent or the real direction of meteoric motion.

This demonstrated result was far from being generally accepted. Alexander Humboldt, with that clear-sightedness which characterised him, even when he was dealing with matters outside his especial range of research, accepted Olmstead's conclusion at once. He recognised meteors and falling stars as travelling with planetary velocities, and even described them quaintly as "pocket planets."

In 1866 new light began to be thrown on Olmstead's demonstrated theory. It was found, first, that the orbits of some meteor systems are such as to carry the meteor families far beyond the paths of even the remote planets Uranus and Neptune. Then it was discovered that some meteor flights travel in the tracks of known comets, as the August meteors in the path of the bright comet of 1862, the November meteors in the path of Tempel's comet of 1866—one having a period of 105 years, the other a period of 33¼ years. But this was not all. Recognising the connection between comets and meteors as demonstrated, I threw out in 1872 the suggestion, or prediction, that when the earth crossed, during the last week of November, the path of Biela's comet, which in that year had crossed the earth's path (though, broken up and disintegrated as the comet had long since been by the sun's action, no telescope had detected its filmy texture), there would probably be a display of falling stars; and on the night of November 27, 1872, the display was seen. Hundreds of thousands of falling stars, all radiating from the part of the heavens corresponding to the known track of the comet, were seen that night; and the whole of the radiant region, at one part of the display, was full of amber-tinted light. Here, then, was another meteor system associated with a comet, and that, too, in a manner which removed even such shreds of doubt as might still have remained in the minds of the more cautious astronomers.

It seemed certain that all meteor systems were associated with comets, all comets followed by trains of meteors, though the origin of meteors and of comets alike, remained still enshrouded in mystery.

Beyond this, indeed, nothing had been proved. Schiaparelli's guess had never been more than a guess—that meteor systems originally travelling along amid the interstellar depths had been drawn into the solar sphere by the sun's action, and that some among them which had chanced to pass near enough to the giant planets to be deprived of a sufficiently large portion of their velocities had been compelled thenceforth to travel on the closed paths recognised in the case of every meteor system yet satisfactorily dealt with. Nay, I think I may say, without showing undue confidence in my own accuracy, that the reasoning sketched in my article on the origin of comets in the *North American Review* sufficed to demonstrate that, whatever the real truth in the matter, Schiaparelli's idea could not possibly be sound. The velocities with which meteors drawn *even from rest* towards the sun would cross the paths of the giant planets, would be such (*demonstrably*) that those planets could not possibly capture the meteor systems, as such, in the way imagined by Schiaparelli.

On the other hand, I advanced a theory whose real force, in my opinion, lay then in the circumstance that it appeared the only theory available; though there was also very strong positive evidence, even then, in its favour. I suggested that as the sun is known to have the power of ejecting bodies from his interior with velocities sufficing to carry them for ever away from him, and as microscopic evidence, chemical evidence, and physical evidence had combined to show that some meteors were once in a condition in which they could never have been save in the interior of bodies like the sun, and his fellow suns the stars, *some* meteors and meteorites have been expelled from suns, and have reached our system after journeys, lasting millions of years, through interstellar space. This, of course, did not account for the meteoric systems associated with the giant planets, as already mentioned—that is, for those systems which, as they pass very near the orbits of the giant planets, had led to Schiaparelli's ingenious but inadmissible theory that they were originally captured by those planets in their swift rush past their mighty orbs. But my theory about the ejection of some meteors from suns like our own was but part of a wider theory. I have long maintained, and it is now I think generally admitted, that every orb in the solar system has once been in a state of intense heat—in fact in a sunlike state. The giant planets have more recently ceased to be suns (in glory as well as heat) than the earth on which we live, or her fellow terrestrial planets Venus, Mars, and Mercury; while the glowing stage of the moon's existence must be set yet further back still. Now when a giant planet was a sun it must have resembled our sun in having the power of gathering its eruptive energies from time to time in such energetic throes that flights of missiles would be ejected from its interior with enormous velocities. Supposing these velocities much less in the case of Jupiter or Saturn than in the case of the great central sun, still they might well be such that the ejected masses would never return to the parent planet; for the simple reason that much smaller velocities would be required to eject missiles beyond Jupiter's back-drawing power, than to eject missiles beyond the much mightier back-drawing power of the sun. Now flights of multitudinous small missiles, ejected in mighty volcanic throes from the interior of Jupiter, would account perfectly for the comets and their associated meteoric attendants which hang around the orbit of Jupiter. And in like manner would the remarkable comet families of Saturn, Uranus, and Neptune be explained.

But we may go a step further in this direction. It has been shown by M. Stanislas Meunier, Tschermak, and others, that among the meteors which fall from time to time on our earth are some which cannot readily be explained unless we regard them as having been once ejected from our earth itself. Of course, the ejection of bodies from the earth to considerable distances had always been regarded as among possible and even probable events. Laplace and Lagrange had considered the problem of such ejection in relation to the theory advanced by Olbers that the asteroids may be the fragments of a former planet, ejected in so mighty a throe that the whole planet went to pieces in its progress. And among the conclusions they deduced was this—that a planet like our earth might very readily eject masses from its interior with such velocities that they would travel thenceforth around the sun as a centre, though with paths intersecting for ever thereafter the orbit of the parent planet. Thus, while a mass ejected from the earth with less velocity would return straightway to the earth, its path necessarily intersecting her globe (since it originated from her globe) these more swiftly ejected missiles would travel on paths which might leave them free to travel for thousands or tens of thousands of circuits around the sun, though eventually the time would probably come when in crossing the earth's orbit they would find the earth herself at the crossing-place, and end their career by returning to the globe from which they had been ejected. Ball has shown that quite a large number of the meteors which fall on the earth most probably had such an origin and such a career.

Now, there is no reason for excepting our earth from the general rule already extended from suns to giant planets. If the theory of the ejection of matter from the sun's interior so that thenceforth it travels meteorwise through space be sound (and it is based on direct evidence), and if the theory of the ejection of matter from the giant planets when in the sunlike state be sound (and it serves to explain the remarkable comet families of the giant planets, apparently explicable in no other way), then we cannot but admit the likelihood, or rather we must recognise the certainty, that the earth also when young and sunlike must have possessed similar power. The power would be less, of course, being proportioned to her mass; but her mass measures also the force which has to be overcome in order to get meteoric matter away with such velocity that it would be beyond the earth's recalling power. Thus, then, while on the one hand weighty evidence tends to show that in the remote past meteoric masses *have* been expelled from the earth's interior so as to travel thenceforth around the sun as their centre, a theory based on direct evidence tends to show that in her youth the earth must have possessed the power to eject such masses from her interior with the necessary velocities. (*To be concluded.*)

Notes.

THE following extract from the official report of the autopsy on the body of Mr. R. A. Proctor, which was sent to the President of the New York City Board of Health, supports the opinion expressed by the Florida medical officials (see page 3) and by Mr. Proctor's relatives, that his death was not due to yellow fever, but that he was suffering from *malarial fever*, when he was exposed on the wet and miserable night of his removal from the New York hotel. The medical man in attendance proposed to take him to the Hospital for infectious diseases at North Brother's Island. But finding the night so stormy, he did not dare to carry him further than a Hospital in Sixteenth Street, not devoted to infectious diseases, where he was taken in at one

o'clock in the morning and placed in an empty ward. He shortly became unconscious, and died the same evening. It is a question for consideration whether the deaths brought about by the official precautions adopted during yellow fever and cholera scares do not outnumber the deaths due to the dreaded scourges themselves. In the particular instance under consideration, it does not appear certain that if the case had been really one of yellow fever, the danger of infection would have been diminished by his removal down the hotel stairs and through the streets. The report states that—

"The only positive change due to disease which could be made out was in the kidneys, which showed the appearance of old, though not advanced, disease. The alterations produced in the body by yellow fever are usually of such a character as to be nearly or completely obliterated by such advanced decomposition as the organs presented. We are, therefore, only able to say in this connection that there was no other evident cause of death, and nothing which would be incompatible with death from that disease. The final conclusion as to the cause of death must, therefore, in our opinion, be largely based upon the clinical history.

T. MITCHELL PRUDDEN, M.D.,
HERMANN M. BRIGGS, M.D.,
Pathologists to the Health Department
of New York City.

* * *

ADMIRAL MOUCHEZ, the Director of the Paris Observatory, where experiments are now being made with regard to the plates to be used for the photographic charts of the heavens, reports that he has received from America some plates which are superior in sensitiveness to any that have been previously employed. The American plates have been tried by the MM. Henry, who report on them most favourably as to the uniformity of film and extreme sensitiveness. They have been able to obtain with one hour's exposure results which were obtained with difficulty in two hours with the best European plates. This is most satisfactory, as the great length of exposure required for fainter stars is one of the chief difficulties in the way of the execution of the photographic chart.

* * *

THE electro-melting process for making aluminium alloys may exercise a considerable influence on the arts in the future. For, according to a paper read before the Franklin Institute by Mr. Pemberton, there is hardly any metal with which aluminium will not alloy, and it alloys with nothing that it does not improve. Aluminium bronze is the strongest of the cast metals, and, when rolled, the strongest of rolled metals. It does not corrode as ordinary bronze does, and its fine golden colour gives it a pleasing appearance. Aluminium brass is noted for its great strength and high elastic limits. Aluminium iron is now extensively used for castings, for the fusing point of wrought-iron is reduced almost 500° by the addition of only one-thousandth of its weight of aluminium.

ANOTHER UNDECIPHERABLE CIPHER.

(*To the Editor of* KNOWLEDGE.)

I WAS much interested in your ciphor in the July number. It is no doubt quite undecipherable in the absence of the key, being based upon the principle of fluctuating signs, which is the only practical principle for a real cryptogram. That is to say, that A shall not always be written down as *x*, but also as *y*, *z*, &c. Your method of obtaining the fluctuations is ingenious and comparatively easy, much more so than the old "Chiffre indéchiffrable"

a b c d
b c d e
c d e f &c., &c.,

used with a prearranged key-word. I doubt, however, whether you gain much by the KNUZTHELOFY part of your system. Is there any real need to indicate the number of letters in each word? Instead of recommencing 2,015, &c., at the beginning of each word, you might run the 20,153,401, &c., right through the message. After a cryptogram has been translated back into a message, the latter is quite legible even though the divisions between the words be not marked. If my suggestion were approved of, you would save writing down the number of letters in each word (2, 3, 8, 2, 3) on your paper of preparation, and also save writing down the corresponding key-word (*nutnuy*) at the commencement of the cryptogram.

I also have invented an "Undecipherable Cipher." It is on the principle of fluctuating signs, but I obtain the fluctuations by quite a different plan to yours, and I should be glad if you will allow me to submit it to a trial by experts in the columns of your paper.

Take any six letters of the alphabet, say, for example, *a c o s u v*. Make them into combinations of twos, thus, *a a*, *a c*, *a o*, &c., in all thirty-six combinations. These will be our signs. Distribute the letters of the alphabet, A B C D E, &c., in any order whatever, amongst the above combinations. This will absorb twenty-six of the combinations. Amongst the remaining ten I distribute an additional letter E, the words And, The, You, the "Letter Repeat," and three "End of Word." The use of these will be explained below.

Our code will now stand thus, for example:—

No. 3.	a a	F	s a	W
	a c	I	s c	Y
	a o	V	s o	M
	a s	T	s s	E
	a u	End of Word *	s u	End of Word *
	a v	D	s v	N
	c a	K	u a	L
	c c	G	u c	Q
	c o	E	u o	X
	c s	S	u s	H
	c u	Z	u u	O
	c v	R	u v	Repeater
	o a	C	v a	The
	o c	End of Word *	v c	
	o o	J	v o	And
	o s	A	v s	You
	o u	P	v u	
	o v	B	v v	U

Three or four codes may be prepared, all of course different.

The first rule for writing the cryptogram is to write all words continuously—that is, without any spaces between them. Thus "We are" would appear as *sacooscvss*. So far, however, the combinations of two letters would in reality have only the same effect as single characters. An enemy, or investigator, by commencing at either end, and dividing the letters into groups of two, would have practically a certain number of single signs, with which he could deal further after the usual analytical methods employed in decipherment.

I come now to the cardinal point and distinguishing feature of my system. At the end of each word the double sign (*au*, or *oc*, or *su*) is written to denote the end of the word, and, after the double sign, a *single* extra false letter (in Code No. 3 either *a*, *c*, *o*, *s*, *u*, *v*) is inserted. *The effect of this single false letter is virtually to change all the succeed-*

ing combinations. Consequently the investigator, though he may divide the cryptogram into groups of two letters, will not succeed in getting at the actual combinations used, but will get others quite different and of no use for his purpose. If an investigator cannot individualise the characters of a cryptogram, how is he to proceed to analyse it? To further guard against certain vulnerable points of cryptograms in general I employ the following simple devices:—

In double letters the second letter is written by the "Repeater." Thus, tt=*asvv.* E has two signs, which are to be used alternately. "End of Word" has three signs, which are to be used alternately. The words "And, The, You" are each expressed by a single sign. This also saves time in writing.

Now for a message. "We are prepared to act" will be written thus:—

No. 3. sacoauvoscvssocuoucvcoouo
scvssavsusasuuauoosoaasocc

This may at first appear longer than a single-letter system, but it is really quicker both to write and to read, because in the single-letter systems the sender must write down the key underneath the whole of the message on a separate piece of paper before commencing his work, and the receiver must likewise write down the key underneath the whole of the cryptogram before he can begin to decipher it. By my method, however, the sender, with his code before him, can jot down the message straight off without any preparation, and the receiver can decipher it in a similar way with even greater speed.

There are some other devices and variations which may be introduced into the system, but I have perhaps said enough to explain the *modus operandi.*

By-the-by, Bacon's five-letter cipher did not fulfil his own condition. It was on the fixed-sign principle, and was decipherable with but little difficulty.

Edward Anderson.

ON A GREAT BRANCHING STRUCTURE IN THE CORONA OF AUGUST 29, 1886.

AMONGST the photographs obtained by the American and English observers who visited the island of Grenada to observe the eclipse of August 29, 1886, is one which, according to the report of Professor W. H. Pickering, shows some enormous structures extending to a distance of nearly two solar diameters from the sun's limb.

The most remarkable of these is a narrow jet in the south-west quadrant which starts from the centre of a group of rays which bend together forming what has been termed a synclinal group, the outer rays of which are inclined inwards from the radial, and then slightly curve together so as to form a hollow cone. There are many such groups on photographs which have been taken during other eclipses, but what is exceptional about this particular group is that from its summit there rises a narrow nearly radial jet which extends without curving to a height of forty-eight minutes of arc (more than a solar diameter and a half), and then divides into three branches, one of which falls over with a crook-like curve towards the western equatorial region, another bends over towards the South Pole, and the third reaches an elevation of sixty minutes, and then falls back towards the equatorial region. To the south of this group is another gigantic jet, which starts with an inclination of twenty degrees or more from the solar radius, and bends over as if it belonged to the same synclinal group, or was under the influence of similar forces to those which caused the bending of the lower rays. This great ray bends over until it appears to cross, or come up to, the hooked ray just below the level at which it branches. The diagram is made from a drawing which Professor W. H. Pickering kindly sent me in a letter shortly after his return.

The larger scale drawing (fig. 2) is made from the frontispiece of the Report of his Expedition recently published. Unfortunately, there is only one photograph showing this remarkable structure, but Mr. W. H. Wesley has in the last number of the *Observatory* put together the outline drawings of this corona made by three observers, which show that as seen with the naked eye there was a great projection at this part of the corona, and the photographs of the English observers, Mr. Maunder and Professor Schuster, corroborate Professor Pickering's photograph as far as they go, that is, they show the synclinal group of structures at the base of the great ray, but the English photographs were taken with longer focussed instruments than that with which Professor Pickering's photograph was taken, and the image thrown upon the photographic plate was less brilliant though larger, consequently the upper and fainter parts of the corona which registered itself with Professor Pickering's instrument cannot be traced upon the English photographs.

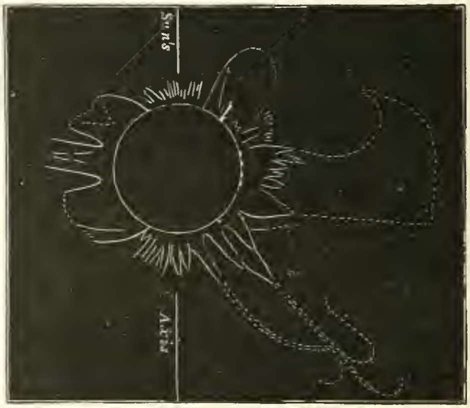


Fig. 1. Outline from Professor Pickering's Drawing.

The structures in question are of a similar character to coronal structures shown on other photographs; for example, the English photographs taken in India during the eclipse of 1871 all show a hook-shaped ray, which, however, does not extend to an altitude of more than eleven minutes above the solar limb, where it divides into two branches which curl over in opposite directions. The main stem or jet is not radial to the sun's limb, but is inclined to the normal at an angle of more than twenty degrees. This curious jet, the photographic evidence with respect to which is quite conclusive, is shown in fig. 3. Its outline is somewhat hazy, as is the case with the jet shown in Professor Pickering's photograph, and it is seen as a somewhat brighter object on a nebulous background. Though it appears small compared with Professor Pickering's jet, it extends to an altitude above the sun's limb greater than the moon's distance from the earth, while the summit of Professor Pickering's jet reaches an altitude of more than a million and a half miles above the solar surface. My intention in this paper is to

inquire what can be the physical explanation of such structures?

The inclination to the radial and the falling back again of the branches towards the solar surface, would seem to show that these structures cannot be due to matter acted upon by a repulsive force similar to that which drives the matter of a comet's tail away from the sun. And these strange forms cannot be explained as due to explosive jets of gaseous matter thrown upward into the coronal region and falling in free space under the influence of gravity alone to the solar surface. Such jets would, in whatever way they were foreshortened by projection, always appear either as straight lines or conic sections about the sun's centre. For a trajectory curve will be projected into a straight line if seen from a point in its plane, or into another conic section if seen from a point outside the plane of the trajectory. The hooks of the great

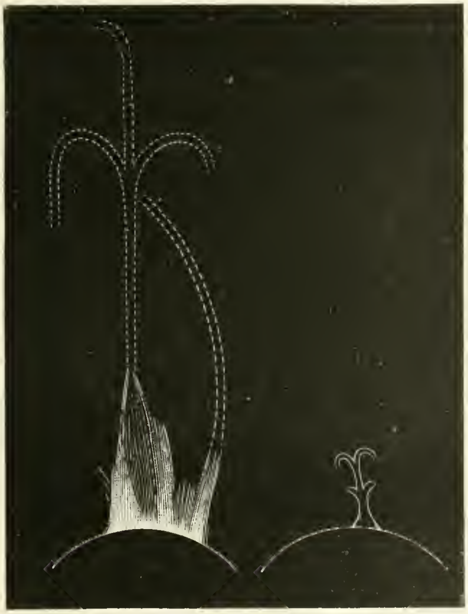


Fig. 2.—Large Scale Drawing of Structure in 1886 Corona.

Fig. 3.—Outline on similar Scale of Structure in 1871 Corona.

jet in the 1871 corona are certainly not conic sections, neither are the branches of Professor Pickering's ray. If in the latter case the three branches belonged to three jets shot up in identically the same path, or all shot up in the same plane one behind the other, so that as seen in projection the upward branches of the trajectories overlapped, the downward branches could not curve away in opposite directions under the influence of solar gravity. Possibly the left-hand hook may belong to the great structure which rises from a part of the limb nearer the South Pole, and the right-hand hook may be the summit of a structure curving from the other side of the synclinal group; but if so, its lower part is fainter and lost to view. One is only driven to such a supposition by the difficulty of conceiving of an explosion at such an altitude producing branches. Clearly we must give up the trajectory theory as being insufficient alone to account for all that is observed. Possibly a theory which supposes jets to be thrown up in true trajectories and afterwards drifted by a resisting medium may be sufficient to account for the observed forms, but there are many mysteries which still have to be cleared up. Why, for example, in the case of Professor Pickering's great ray, should the falling branches be drifted, while the upward branch remains absolutely straight.

It may be useful here to point out some of the possible changes in the form of a structure which may be due to perspective. A straight ray whose direction passes through the sun's centre cannot be projected so as not to be radial to the sun's limb; but a straight ray which appears radial as seen in projection, may possibly be inclined to or from the observer, and may be very far from normal to the sun's surface at the part of the photosphere from which it springs. A ray which does not appear radial as seen in projection cannot be normal to the solar surface. There is ample evidence in the coronal photographs of the existence of such oblique rays. It is difficult to conceive how explosions from a gaseous body like the sun can give rise to oblique rays, but their existence is beyond dispute. They are, I believe, without exception brighter, and they are frequently broader in their lower parts—sometimes appearing to spring from a broadened base like a bulbous root, which may be due to a real broadening of the ray, or to overlapping smaller rays at its base.

Some of these oblique rays are straight, or nearly straight, while others show considerable curvature, and others bend over in one direction in their lower parts, and are again carried slightly in a contrary direction above. The existence of these curving rays, showing contrary flexure, is a matter of considerable importance, as they appear to indicate the existence of an atmosphere with currents carrying the matter of which the structures are composed with different velocities at different altitudes.

And yet anything like a gaseous atmosphere, where each layer presses upon and is supported by the layer beneath it (as in the case of the terrestrial atmosphere), is inconsistent with other solar phenomena. For example, it is inconsistent with the small amount of light dispersed by the corona, and it is inconsistent with the narrow spectral lines given by the prominences which correspond with a gaseous barometric pressure of less than a hundredth of a terrestrial atmosphere; with solar gravity in the prominence region twenty-seven and a half times greater than terrestrial gravity at the earth's surface, it follows that, if the solar atmosphere were in static equilibrium, the pressure would (assuming uniform temperature) be doubled at a level an eighth of a mile lower; at a depth a mile and a quarter lower down the pressure would be multiplied by 2 to the power of ten, that is, it would be more than a thousand times as great as at the upper level; at a depth of five miles the pressure would at this rate be more than a million million times as great. No reasonable assumptions with respect to rapid increase of temperature would counterbalance such an overwhelming rate of increase of pressure. The gaseous molecules and dust particles which spectroscopic and polariscopic observations show are present in the corona, must either be moving freely in very long trajectories, or they must be maintained in position by some force counterbalancing gravity, similar, for example, to the force which repels the matter of a comet's tail.

Be that as it may, there is certainly resisting matter in the coronal region which retards the upward flight of the matter of solar prominences. This was first definitely shown to be the case by Mr. Proctor, and was an important step in the solar theory. In a paper published in the *Monthly Notices* of the Royal Astronomical Society, for

December 1871, he compared the velocity of the matter of a hydrogen prominence observed by Professor C. A. Young with the velocity of a projectile thrown upward in free space under the influence of solar gravity, and showed that the observed velocity indicated that the prominence matter was moving in a resisting medium. There are not many cases in which suitable observations of the velocity of the rise of a great prominence have been made, but I have since made a similar calculation with respect to another great prominence observed by Professor Young in October 1879, and have derived a similar result. The motion of comets with close perihelion distances also points in the same direction, and there seems to be little room for doubt that the jets of coronal matter as well as the prominences are projected into a resisting medium which is itself in motion, and rapidly modifies the projection forms.

A. C. Ranyard.

FAIRIES OF FRANCE, ITALY, AND SPAIN.

By Mary Proctor.

In olden times the peasant in Gaul believed that wondrons deities haunted every stream and dale. Even now, as the village dames sit at their cottage doors knitting, the children gather round and listen eagerly to the oft-told tales of those good old days. But dainty little fairies have now taken the place of gods and goddesses.

They are very beautiful, and particularly fond of dancing in fairy rings on the green sward, which are called Cercles des Fées, but woe to anyone who approaches whilst the fées are dancing therein. They are forced to join in the dance, and, as they whirl round faster and faster, they become so weary that they fall down exhausted, and are lucky if they escape with only a few bruises.

Near the village of Puys there is a high plateau where the "fées" used to hold fairs, at which they sold magic articles taken from their secret stores. They would use all their persuasive powers to make mortals buy these, but when the purchaser would hold out his hand to take the chosen article, the perfidious "fées" would hurl him down the side of the cliff.

In days of old a merry band of fairies haunted Normandy, and were called Les Dames Blanches. They were always on mischief intent, and would hide themselves in dark nooks and narrow ravines ready to spring out on the unwary traveller. They would often insist upon his dancing with them, and, after a round or so, they would dismiss him gracefully, but should he refuse, they would fling him into a ditch full of briars and thorns.

A very imperious Dame Blanche once haunted a narrow bridge over the Dive, in the district of Falaise. She would not let anyone pass by until they went down on their knees to her. If they refused, they were delivered over to the tender mercies of the lutins, cats, owls, and other creatures over whom she held sway.

Lutins were little beings, very much like the kobolds and nisses of Scandinavia and Germany. They would be very kind to little children when they were good, and give them cakes to eat, but, when they were naughty, the lutins would pinch them and make them feel very sorry.

A story is told about an old grandmother who had a great deal of trouble with seven little boys. They would play on the seashore after dark, and she was always afraid something dreadful would happen to them. One evening, when they were having an especially fine frolic, a little boy spied a pretty black horse, and he suggested to the others that they should all get on his back and ride home. So they mounted the horse, and on their way home they met several of their playmates, whom they invited also to take a ride. Now, it may appear strange, but the little horse had conveniently stretched its back so far that it carried thirty little boys quite easily. Imagine their horror, however, when the magic steed suddenly bolted with them into the sea, and, plunging far under the waves, the naughty little boys were all drowned.

Another lutin, named Le Petit Homme Rouge, was very angry with some little children who made fun of him. He pelted them so hard with stones that they hid themselves under an old fishing-boat. They heard the shower of stones on every side; but, when they at last ventured to peep out, not a stone was to be seen. Nevertheless, they had learned a good lesson, they were not likely to forget in a hurry.

There are fairies resembling the lutins who have been known to steal horses out of the stables and take many a wild ride across the country. They would sit on the horse's neck, and plait the mane together for stirrups. Sometimes they would work with the tools they found in the stables, but everything would be in perfect order next morning, and the tools mended if they needed repair. Besides, the farmers liked to have the bright little beings around the place, for they invariably brought good luck, and were kind and obliging, helping those whom they liked with their work.

The Esprit Follet, or Gobelin of the North of France, resembles the domestic sprites of Germany, and is full of mischief. They haunt the cottages of the peasants, and pelt people with sticks and stones as they pass in and out of the doors. Though their little cracked voices are often heard, yet they have never been seen, so that it is impossible to drive them out. They have been known to enter houses suddenly, taking children out of their cradles, blowing out the lights, and even worrying those who were sleeping. The peasants found to their great distress that all the holy water in the church was of no avail against these mischievous sprites!

In Besançon, the meadows are supposed to be haunted on dark nights by these frolicsome little beings. A charming account is given of one in the story of "La Petite Fadette."

"C'était vraiment une vilaine chose à voir. Tantôt il filait comme un martin pêcheur, et tantôt il disparaissait tout à fait. Et d'autres fois il devenait gros comme la tête d'un bœuf, et tout aussitôt menu comme un œil de chat; et il accourait auprès de Landry, tournait autour de lui si vite, qu'il en était ébloui, et enfin, voyant qu'il ne voulait pas le suivre il s'en retournait frétiller dans les roseaux où il avait l'air de se fâcher et de lui dire des insolences."

In the south of France the peasants still believe in fées, or fadas, as they are sometimes called, and there is not a village in Languedoc without some little nook or spring frequented by them.

In Provence a special feast is prepared for them on the night of December 31. A room is set apart for their use, and the doors and windows are left open as an invitation for them to enter. A table is spread with a snow-white cloth, on which are placed a loaf, a knife, a vessel full of wine or water, a plate, and a lighted candle.

According to the old romances, three fées would go to each house:—

Coustume avoient les gens, par vérités,
Et *en Provence* et en autres regnez.
Tables métoient et siéges ordenez,
Et sur la table iij blanc pains bulétez,
Iij poz de vin et iij hénez de lès
Et par encoste ieit li enfès posez.*

* Possibly G. Sand's story of "Les Dames Vertes" was founded on this myth.

In the Romance fairy tales, as in the French, the old Roman gods gradually assumed the nature of wood sprites and fairies. The Lars, closely akin to the Gothic dwarfs, were supposed (like the Grecian heroes) to be the souls of men who after death were doomed to hover about their former abodes.

The fata of Romance tales were supposed to exercise a wonderful influence over the destiny of mortals. There were, according to the Italian poets, black and white fates, good and bad.

The most celebrated, called the Fata Morgana, was the queen of the fairies, and the wonderful mirage to be seen at Messina was supposed to be a reflected image of her palace under the waters. She is the goddess of fortune, and subject, with all the fates and witches, to the terrible Demogorgon. According to Ariosto, he has a splendid temple-palace in the Himalaya, where the fates are all summoned to appear and give an account of themselves every fifth year.

"They travel through the air in various strange conveyances, and it is no easy matter to distinguish between their convention and the Sabbath of the witches." *

A fata, called Silvanella, was supposed to have built a tomb over Narcissus and then dissolved away into a fountain. When the tomb was opened by Brandamarte (an Italian hero), a hideous serpent put forth its head. He kissed it, and it gradually changed into a beautiful maiden, possibly Silvanella.

Among the collection of fairy tales to be found in the Pentamerone, the following is related about the fairy Colina.

A poor fisherman had had so much ill-luck that at last, in despair, he called on the Enemy to help him. The latter did so, on condition the fisherman should give him his youngest son when he was thirteen years old. The fisherman agreed to these strange terms, and from that day was always successful.

At last the time arrived for the Enemy to claim the boy, and the fisherman bitterly regretted the rash promise he had made. He had not the heart to see the boy taken, so he placed him on the beach at the appointed place, and bade him wait till he returned from his fishing.

The boy amused himself by making wooden crosses, and sticking them around him in the sand. When the Enemy appeared and saw these crosses, he frowned at the boy, and bade him destroy them. At first the boy refused, but being afraid of this terrible being, he destroyed all but the cross he held in his hand.

Although the Enemy rolled his eyes and looked very terrible, yet he could not persuade the boy to obey him. Presently a bright light appeared in the sky, and the fairy Colina, queen of the fairies, descended, and seizing the boy by the hair of his head, carried him off to her palace. There he became a general favourite, and the fairy queen chose him for her bridegroom.†

In Naples the good people had a superstitious belief in a little being called the Monk of Monaciello. He is described as a little man, dressed like a monk and wearing a broad-brimmed hat. He appears to people during the night, and beckons them to follow him. If they have the courage to do so, he leads them to a place where great treasures are concealed, and in this way people have become suddenly rich.‡

This little being resembles the Spanish Duende, or house-sprites, who are mischievous and spiteful, often pelting people with sticks and stones.

* Keightley's "Fairy Mythology," p. 452.

† "Italian Popular Tales." T. F. Crane, p. 136.

‡ The Monaciello is closely akin to the German Nis or Kobold, which may be accounted for by the fact that the Normans settled in Naples. Keightley's "Fairy Mythology," p. 450.

Although very little is known about the fairy folk-lore of Spain, yet it shows a strong resemblance to the folk lore of France, Italy, and even Germany.

In Catalonia there is said to be a deep lake on the summit of a mountain. If a stone is thrown into this lake, a terrible storm rages, and the waters bubble and boil in a most alarming way. This may be the lake of boiling pitch referred to in the story of "Don Quixote," under which a fair princess was imprisoned. At the bottom of this lake there is a palace with a wide gate, through which none enter but the demons and their captives and the fairies who inhabit this place.

Many years ago a man was annoyed by a little girl, who was crying, and he wished that the demons would be off with her. Instantly she vanished, clutched by invisible hands, and it was seven years before she was seen again. She came as she went, "like a sudden gust of wind." She was tall in stature, but wasted and dirty, her eyes rolling wildly, and her speech inarticulate.

Possibly the demons were some kind of fairies, or the spirits of fallen angels, according to the Spanish belief. This may account for a strange request, once made by a fairy, whom a mortal had chosen for his bride. She imposed the condition that a holy name should never be mentioned in her presence, to which her husband agreed. Unfortunately, seeing one day some dogs quarrelling over a bone, he exclaimed,

"Holy Mary! Did you ever see the like?" At once the beautiful fairy bride glided through the air, and disappeared in her mountain home.

Many years after her husband was thrown into prison by the Moors, and being told that his wife alone could save him, he sent their son to her. As the boy approached the well-known mountain, "behold! his fairy mother stood there before him on the summit of a rock."

She gave him a steed called Pardalo, and bade Iniquez mount him, and not unsaddle or unbridle him nor put shoes upon his feet, and in one day the steed would carry him to Toledo. He did as he was told and rescued his father, but his mother never returned to their home.

Many stories are told about the little beings who haunt the woods, and who are sometimes seen and heard by fortunate mortals.

Pepito El Corcovado, a lively little hunchback, was returning home one evening from a wedding, where he had been playing his guitar and singing. He lost his way in the woods, and, as night was coming on, he wrapped his cloak around him, and fell asleep at the foot of a cork tree.

All at once he was awakened by the sound of little voices singing a well-known air. They would only sing the first line, but Pepito joined in and sang the whole strain. The little folks were so delighted, that, as a reward, they made him straight as a poplar, and his hump disappeared for ever.

ON LIFE-RESTORING.

By Professor Preyer.*

(Extracted from "The Open Court.")

If we were able to freeze a plant or animal's body through and through, to dry one up thoroughly, to preserve one for a year wholly apart from the air in a cold exhausted space without food and without water, so that on an appointed day, after the admission of moist air, it would start up in the heat and continue to live without the least injury to its health—just as if

* Translated from the German by F. W. Morton.

nothing had happened—then our methods of investigating living bodies would be essentially simplified, and we might hope to establish the necessary conditions for each separate function.

This production of life at pleasure, this winding up and stopping the clock of life, is in some cases subject to the will of man. Nature herself performs the experiment millions of times, on a large scale or on a small one, on plants and animals, on seeds and eggs, as well as on completely formed beings, when in summer it dries up the organic dust and then after weeks of drought restores it to life by invigorating rains, or when by currents of air nature transplants it to damp regions and awakens it to new life.

The unwearying Leeuwenhoek was the first to make these fundamental observations. In his 144th letter on the revealed mysteries of nature he describes a series of infusoria, especially radiate animals, which on August 25, 1701, he found in the water of a house gutter. This water he evaporated, and when, as late as February 1702, he took up the dry residue, he saw, to his great astonishment, that without exception the infusoria came to life again on being moistened with pure rain water. He thought that all the species resuscitated by him had thick shells which in the process of drying did not permit the water in the interior to evaporate. But this view, which was shared by later scientists, is incorrect, because the surrounding skin or shell—which does not exist on all species—is not so thick as would be required for this. The animals rather shrink enormously, as may easily be seen with powerful magnifying glasses, so that they become unrecognisable and evidently do not contain water within the crust or shell. It is also possible in fifty-seven other infusoria, especially in dried *ursuli*, to note the swelling of the body and the extremities when they are moistened. This is one of the most beautiful spectacles which the microscope affords, for we *see* how the supposed particles of dust which only an adept can distinguish from the surrounding real dust, and then principally by their colour, are brought into life.

The second observer was Turbervill Needham. In the summer of 1743 he discovered in diseased wheat little eel-like bodies which were wholly motionless and formed a thick confused mass. He moistened them, so as better to observe the supposed fibres, and was highly surprised when they thereupon became alive. He was greatly perplexed at this accidentally discovered fact. He kept the mites for two years in a dry place, and ever and again they would come to life through the influence of water. His observations were confirmed and extended in the same year by Henry Baker. This scientist saw the dried animals come to life by moistening after the lapse of twenty-seven years, just as after a few years. Similar results in respect to the same subject were attained somewhat later by Buffon, who established his priority against the great physiologist Fontana, who, independently of all others, made the same discovery in 1767. Buffon's account, however, is somewhat poor; and when he correctly observed and compared the anguillulæ with little machines, he confused this good thought by his broader, phantastic statements respecting the living molecules.

Fontana, with brilliant success, extended his attempts at resuscitation to other animals. He dried, besides the anguillulinæ, especially radiate animals, a hair worm, and then brought it to life again by means of water. He felt called upon "to speak of this little wonder in a special treatise under the title, 'On the Life and Apparent Death of Animals.'" This treatise, however, is not extant.

The most extensive investigations respecting the resuscitation of lifeless animals were made by Spallanzani, who, in 1776, published in Modena his great work on animal and plant physics. By drying them he could make the same rotifers lifeless, and by moistening them restore them to life eleven times. He found further that even at 19° below the freezing point of water and at a comparatively stronger degree of heat the dried animals still retained vitality. He it was who discovered the *ursuli*, which are especially serviceable for such experiments, and which, being equipped with nerves, muscles, and eyes, are far more highly organised than any other animals revivified by him.

This remarkable creature was first experimented with by C. A. S. Schultze, the first German scientist who turned his attention to the resuscitation of life. Discovered in Holland, confirmed in England and France, extended and more accurately established in Italy, the fact of revivifying small organisms made the rounds of half Europe without even a *single* fundamental investigation being made in Germany during more than a century. And after Schultze had published his observations in 1834 the fact was doubted by German scientists, and indeed utterly denied by Ehrenberg. In 1838, therefore, Schultze, on the occasion of a scientific convention in Freiburg, again set forth his discoveries. Here he showed those animals which had been called shell-animals, by Hufeland, but which he had named *macrobiotus* on account of their longevity. But Ehrenberg's strange explanation that presumably the supposed reanimated individuals were the descendants of the dried ones still for a long time kept scientists from accepting the new views.

Above all, the experiments with freezing are convincing. These can be performed with success on higher animals. Frogs, as I myself have repeatedly shown, can be frozen in all conditions to solid ice, so that the slightest trace of life no longer exists, so that no sign of vitality can be elicited from them by the greatest irritation, and then again come to life after having been thawed out, and appear just as before the experiment. Duméril, in 1852, performed such an experiment with entire success. Many fishes, we know, especially the pike, can be frozen through and through or be left lying in the air, and still be revived on being moistened with water.

With warm-blooded animals only a very few experiments of this sort have been tried. Still it is known that a few may be frozen even to the entire cessation of the heart's action and breathing, even to the complete disappearance of nervous and muscular sensibility, and then by careful heating become, for a time at least, alive again. And the chicken in the egg, before hatching, can be so greatly reduced in temperature that the action of the heart ceases, without suffering injury, if after a couple of days the normal heat is restored. It merely hatches so much smaller, since it cannot regain the lost time. Fresh eggs, again, which have been frozen to solid ice, have developed, after gradual thawing, with complete regularity in the process of incubation.

Reviews.

British Reptiles and Batrachians. By CATHERINE C. HOPLEY. (London: Swan Sonnenschein & Co. 1888.)—We shall be much surprised if the persual of Miss Hopley's most interesting volume does not lead to the setting up of reptilian vivaria by a large number of people who, prior to reading it, classed toads, frogs, lizards, and newts generally as "horrid things," and who have fled from every snake which they were unable to kill in the wildest alarm. This her latest addition to the capital "Young Collector" series fully sustains the reputation of that excellent issue,

and should be read by all who wish to know something of forms of life at present unfamiliar to a large proportion of people on account of the superstitious horror of and prejudice against them which seemingly forms part of our inheritance. We strongly advise our readers to purchase and study this absurdly cheap little work.

The Mechanic's Workshop Handybook. By PAUL N. HASLUCK, A.I.M.E. (London: Crosby Lockwood & Son. 1888.)—Mr. Hasluck's latest volume will be found alike useful by the artificer and the amateur. Dealing with the manipulation of metals, it enters in detail on such subjects as alloys, forging, welding, annealing and hardening, soldering, lacquering, drilling, filing, grinding, &c. Five pages and a half of index in very small type may suffice to indicate what a mass of diverse information is packed between the two covers of the volume before us.

Electroplating. By J. W. URQUHART, C.E. Second Edition. (London: Crosby Lockwood & Son. 1888.)—Like all the Messrs. Crosby Lockwood's publications, the one before us is eminently practical, and may be studied with advantage at once by the amateur and by the professional worker in the plating-shop. Batteries, dynamos, baths, &c. &c., are carefully and intelligibly described, while the special methods employed in the electro-deposition of the various metals are excellently explained in detail. Mr. Urquhart has produced a work of enduring value.

THE FACE OF THE SKY FOR NOVEMBER.

By F.R.A.S.

THE sun may be watched for the small spots which appear at distant intervals on his surface. Map xi. of "The Stars in their Seasons" exhibits the aspect of the night sky. Minima of the variable star Algol ("The Stars in their Seasons," map xii.) will happen on November 2 at 5h. 17m. P.M.; on the 17th at 1h. 22m. A.M.; on the 19th at 10h. 11m. P.M.; and on the 22nd at 7h. P.M., as well as on other occasions less convenient for observation. The student should watch (*after midnight*) on the nights from the 12th to the 14th for the shower of shooting stars radiating from the "sickle" of Leo. He may also look out on the night of the 27th; in fact, November is a month prolific in these visitants from space. Mercury is a morning star all through November, and attains his greatest elongation (19° 26′) west of the sun on the morning of the 17th. Towards the end of the month he may be seen with the naked eye in the SE. by E. before sunrise. Venus is an evening star, but her south declination is so great that she is visible with difficulty, if at all. Mars and Jupiter are both invisible, as is Uranus also. Saturn may be seen in the eastern sky by midnight to the WNW. of Regulus ("The Stars in their Seasons," map iii.). Neptune is in Taurus a little to the west, and just to the south of the 6th magnitude star ω^1 in that constellation a line drawn from Aldebaran through δ Tauri ("The Stars in their Seasons," map i.) if prolonged rather more than as far again will pass pretty close to Neptune's place. The moon is new 2·1m. after midnight on the 3rd; enters her first quarter at 4h. 15·8m. P.M. on the 10th; is full at 3h. 15·9m. P.M. on the 18th; and enters her last quarter at 5h. 20·5m. P.M. on the 26th. Four occultations of fixed stars by the moon will occur at fairly convenient hours during the present month. The first happens on November 6, when B.A.C. 5954, a star of the 6th magnitude, will disappear at the moon's dark limb at 6h. 13m. P.M., at an angle of 75° from her vertex; but she will have set ere it reappears. On the 12th, ψ^3 Capricorni, a 5th magnitude star, will disappear at 5h. 9m. P.M. at the dark limb of the moon, at an angle from her vertex of 103°. It will reappear at her bright limb at 6h. 21m. P.M., at a vertical angle of 267°. On the 19th, *i* Tauri, of the 5½th magnitude, will disappear at the bright limb of the moon at 9h. 57m. P.M., at an angle of 153° from her vertex; reappearing at her dark limb at 10h. 9m. P.M., at an angle from her vertex of 174°. Lastly, on the 21st, 15 Geminorum, a star of the 6th magnitude, will disappear at the moon's bright limb at 7h. 15m. P.M., at a vertical angle of 346°. Its reappearance at the dark limb will happen at 7h. 29m. P.M., at an angle of 315° from the vertex of the moon. The moon is in Virgo at noon to-day ("The Seasons Pictured," plate xxv.), and is travelling across that great constellation until 2h. P.M. on the 3rd, when she enters Libra ("The Seasons Pictured," plate xxvi.). As she crosses Libra she arrives, at 4h. 30m. A.M. on the 5th, on the western edge of the narrow northern spike of Scorpio; by 1h. P.M. on the same day she has traversed this and emerged in Ophiuchus. By 11 P.M. on the 6th the journey over Ophiuchus is completed, and she passes into Sagittarius. Here she remains until 5h. 30m. A.M. on the 9th, at which hour she quits Sagittarius for Capricornus ("The Seasons Pictured," plate xxi.), which she leaves in turn for Aquarius at 2h. 30m. A.M. on the 11th. She remains in Aquarius until 6h. A.M. on the 13th, and then crosses into Pisces ("The Seasons Pictured," plate xxii.). Travelling through Pisces, she enters the north-western part of Cetus at midnight. She re-enters Pisces at 9 A.M. on the 15th, only, however, to plunge again into Cetus at 8h. A.M. on the 16th, whence, at midnight of the same day, she passes into Aries ("The Seasons Pictured," plate xxiii.). She remains in Aries until 3h. A.M. on the 18th, and then leaves it for Taurus. Journeying across Taurus, we find her, at 5h. A.M. on the 21st., close to the northernmost portion of Orion. By 2h. 30m. the same afternoon she has traversed this and emerged in Gemini ("The Seasons Pictured," plate xxiv.). At 2h. P.M. on the 23rd she passes out of Gemini into Cancer, leaving Cancer in turn for Leo at 5h. A.M. on the 25th. She is travelling across Leo until 11h. P.M. on the 27th, when she crosses the boundary into Virgo ("The Seasons Pictured," plate xxv.). She is close to the confines of Virgo and Libra at midnight on the 30th.

Our Chess Column.

By "MEPHISTO."

CHESS IN HOLLAND.

THE following fine games were recently played at Amsterdam. The openings, in both cases, are interesting specimens of two of the best and most difficult variations in the Spanish *début*, and the middle and end-game is of a brilliant and pleasing character, doing credit to both victor and vanquished. It may be stated that Mr. Loman, the winner, has recently won the first prize in the Dutch National Tournament, but that he has lost a majority of games against Herr D. van Foreest, his unsuccessful opponent in the two games given below:—

SPANISH.

WHITE. R. Loman.	BLACK. D. van Foreest.
1. P to K4	1. P to K4
2. Kt to KB3	2. Kt to QB3
3. B to Kt5	3. P to QR3
4. B to R4	4. Kt to B3
5. Castles	5. Kt × P
6. P to Q4	6. P to QKt4
7. B to Kt3	7. P to Q4
8. P to QR4	

Played by Tchigorin against Rosenthal in 1883. It seems to be the natural continuation against the weakened Queen's side.

8. P to Kt5

This move creates still more looseness in Black's position, particularly as he has not yet Castled, and in similar positions it is always doubtful whether the weakened party will get the time for bringing his King into safety. We would prefer QR to Ktsq, but not without misgivings as to the future prospects.

9. P to R5

9. P × P

White threatened P × P, and to win the QP afterwards.

10. Kt × P

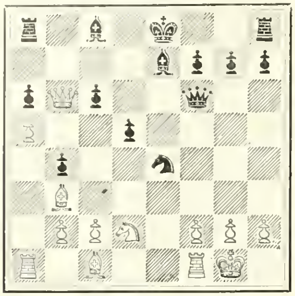
If 10. B to R4 instead, Black defends with B to Q2. 11. B × Kt, B × B. 12. Kt × P, B to Q2. 13. P to KB3, Kt to B4, &c.

	10. Kt × Kt
11. Q × Kt	11. P to QB3
12. Kt to Q2	12. Q to B3
13. Q to Kt6	13. B to K2

Up to White's last move the position is identical with the above-mentioned game, but Rosenthal here played Kt × Kt instead of Black's move of B to K2. It is interesting to note that Mr. Wayte, remarking on Black's 13th move of Kt × Kt said, If, instead, 13. . . . B to K2, 14. Kt × Kt, P × Kt, 15. B to Kt5! This actually happened in this case, and speedily turned the game in White's favour. Of course, if Black plays Kt × Kt, 14. B × Kt, and he loses the QKtP.

Position after Black's thirteenth move, B to K2 !

BLACK.



WHITE.

14. Kt × Kt	14. P × Kt
15. B to Kt5 !	15. B to Qsq

If Q to Kt3, then after 16. B × B, K × B, 17. Q × P (ch), White has a winning position.

16. Q to B5	16. B to K2
17. Q to B4	

And the game terminated in White's favour as per above note.

WHITE. R. Loman.	BLACK. D. van Foreest.
1. P to K4	1. P to K4
2. Kt to KB3	2. Kt to QB3
3. B to Kt5	3. Kt to B3
4. Castles	4. Kt × P
5. P to Q4	5. B to K2
6. Q to K2	6. Kt to Q3
7. B × Kt	7. KtP × B
8. P × P	8. Kt to Kt2
9. Kt to Q4	9. Kt to B4
10. R to Qsq	10. B to Kt2
11. Kt to B3	11. Castles

So far again all is book, but we do not at all like this variation, especially if the Black QB has to play to Kt2, which enables White to proceed more freely against the King's side by Q to Kt4, as he is not threatened with P to Q4.

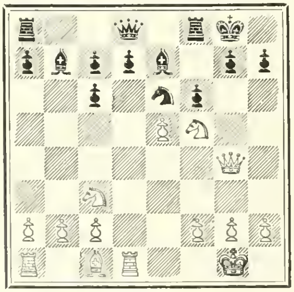
12. Q to Kt4	12. P to KB3

This move at times turns out well for Black. There is, however, always a certain amount of danger in it. In the present instance, K to Rsq seems the safest move.

13. Kt to B5	13. Kt to K3

Position after Black's thirteenth move, Kt to K3.

BLACK.



WHITE.

14. Kt × P

Very good move. White's attack against the King's side always proceeds on similar lines in this opening, though the moves may vary. A similar game was played by Locock against Gunsberg in the recent Bradford Tournament, the former player very nearly carrying the assault to a fatal termination for Black. For the sake of comparison we give this game below.

	14. Kt × Kt
15. B to R6	15. R to B2
16. P to K6	16. P × P

Black must give up his Queen, as otherwise he will be worse off.

17. R × Q	R × R	24. R to K6	P to B5
18. B × Kt	R × B	25. Kt to K4	P × P
19. Q × P (ch)	K to Rsq	26. RP × P	P to B4
20. R to Qsq	R to KBsq	27. Kt to B6	B to K2
21. R to Ksq	B to Q3	28. Q to QB3	B × Kt
22. P to KKt3	P to KB4	29. R × B	R to Qsq
23. Q to Kt3	B to Rsq	30. K to R2	Resigns

White has conducted the game soundly and effectively. Black has not much chance left.

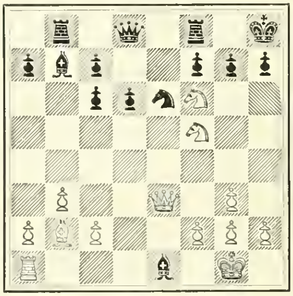
PLAYED AT THE BRADFORD TOURNAMENT.

WHITE. Locock.	BLACK. Gunsberg.	WHITE. Locock.	BLACK. Gunsberg.
1. P to K4	P to K4	11. R to Ksq	R to Ktsq
2. Kt to KB3	Kt to QB3	12. P to QKt3	Kt to K3
3. B to Kt5	Kt to B3	13. Kt to B5	B to Kt5
4. Castles	B to K2	14. Q to K3	P to Q4
5. P to Q4	Kt × KP	15. P × P *en pas*	P × P
6. Q to K2	Kt to Q3	16. B to Kt2	B to Kt2
7. B × Kt	KtP × B	17. Kt to K4	B × R
8. P × P	Kt to Kt2	18. Kt to B6 (ch)	K to Rsq
9. Kt to Q4	Castles	19. Q to R6	
10. Kt to QB3	Kt to B4		

White's last move was a miscalculation. He imagined that, after P × Q, he could proceed with 20. Kt, discovers check K to Ktsq ; 21. Kt × P mate, overlooking that Black could interpose his P on B3. White had a very good continuation in Kt × P, as may be seen on examination of the position given in the following diagram :—

Position after Black's eighteenth move.

BLACK.



WHITE.

If White plays 19. Kt × KtP, Black cannot retake with Kt on account of 20. Q to R6. Also if 19. K × Kt Black would be mated by 20. Q to Kt3 (ch), K to Rsq, 21. Q to R4. The only move for Black to prevent Q to R6 seems to be 19. . . . B × P (ch), 20. K × B, Q to Kt3 ; 21. Q × Q, P × Q ; 22. Kt to B5, and White should win.

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CONTENTS.

THE VOLCANOES OF THE SANDWICH ISLANDS,

AND THEIR BEARING UPON VOLCANIC ACTION IN GENERAL.

By W. H. WESLEY.

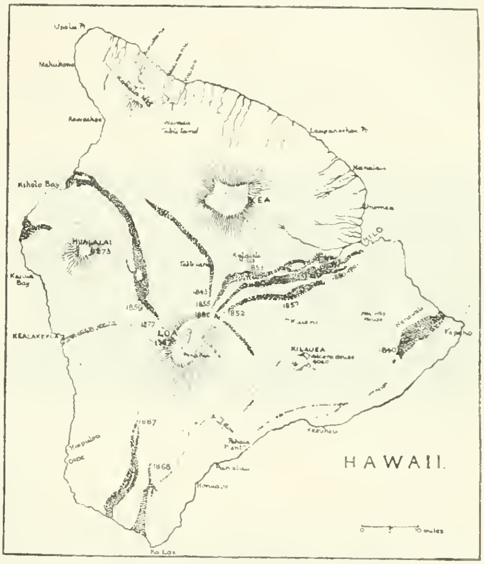
FOR many years after the discovery of Hawaii by Captain Cook in 1778 the visits of Europeans were few and far between, and the interior was long considered inaccessible. Our first accurate knowledge of the crater of Kilauea dates from the time of Mr. Ellis's visit in 1823. Since then we have, in the accounts of travellers and missionaries, sufficient material for a history of the Hawaiian volcanoes.

The eminent American geologist, Professor J. D. Dana, has lately published in the "American Journal of Science," vols. xxxiii.–xxxvi., a series of papers in which he has collected the accounts of all known eruptions of Mount Loa and of Kilauea. He has also compared their action with that of volcanoes in other parts of the world, and considered the light which they throw upon the difficult problems of volcanic action.

The loftiest mountain in Hawaii is the extinct volcano of Mount Kea, 13,805 feet; the highest active volcano (described by early travellers as also extinct) is Mount Loa, 13,675 feet. Kilauea is situated on the western slope of Mount Loa, at an altitude of 4,040 feet above the sea.

But little is known of changes which may have taken place in the crater, which is three miles long, on the summit of Mount Loa. Since 1832 all the known outflows of lava have begun at various distances below the summit. In 1834 Mr. D. Douglas, who was the first to ascend the mountain, looked into the interior of the crater from its rim, which he measured as more than 1,200 feet in height, and saw a desolate lava-covered plain $3\frac{1}{2}$ square miles in area, with deep chasms from which hissing sounds proceeded, as though from some great internal fire. In 1841 the crater on the summit was surveyed by Captain Wilkes, who gave the height of the walls as from 784 to 470 feet.

In January 1843 one of the greatest eruptions commenced. Mr. Coan and Mr. Andrews saw a brilliant light at the summit, which lasted for a week, and about 700 feet



THE ISLAND OF HAWAII.

lower down a great discharge of lava flowed for more than six weeks, extending for a distance of over twenty miles. Mr. Coan found in the crusted surface of this stream many large steaming openings, down which he saw the lavas rushing along a tunnel-like way with awful speed some 50 feet below us. "Large stones thrown on the surface were carried instantly out of sight before sinking in the stream."

A great eruption occurred in 1852: the escaping lavas first rose in a lofty fountain, which was approached by Mr. Coan on its windward side within 200 feet; he found its height by angular measurement to be from 400 to 700 feet. The lava ascended continuously with "a roar like that of Niagara," says Mr. Kinney, another observer, who estimated the diameter of the opening from which the fountain flowed as about 1,000 feet. The lava stream in some places had a depth of 200 to 300 feet.

In 1855 Mr. Coan estimated the rate of the flow, as seen from the fissures in the crusted surface of the stream, to be forty miles an hour; this may possibly have been an over-estimate. But the observation was made near the source, and at the front of the stream, where the lava had spread over a large surface and met with many obstructions, the rate was a mile a week. Owing to the cooling and the partial damming of the stream along the front, the hardened upper stratum was raised into numerous domes and tumuli, some as much as 100 feet high. Layer was added to layer, increasing the thickness from a few feet to 50 or 100. "After flowing freely for a time, the stream sometimes cooled and hardened along the front, remaining inactive for some days, till at length immense areas of the solidified lava some miles above the extremity were again in motion, cones were

uncapped, domes cracked, hills and ridges of scoria moved, and immense slabs of lava were raised vertically or tilted in every direction."

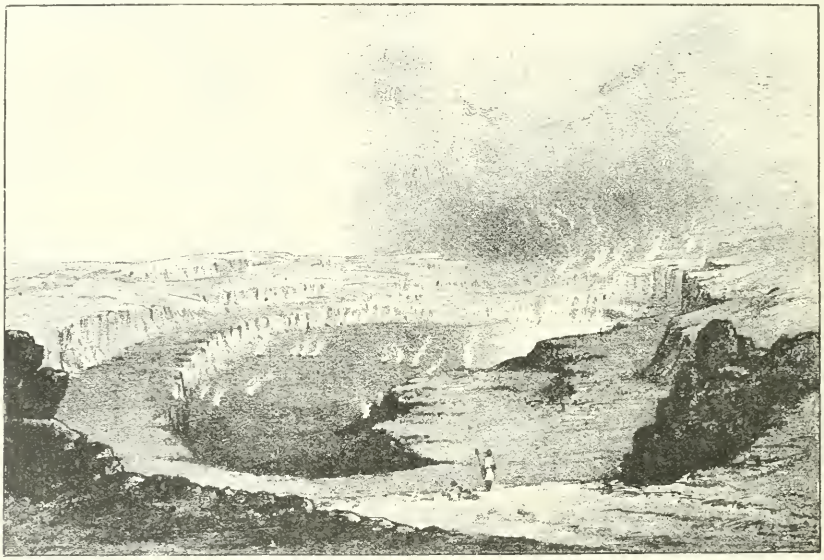
In 1859 there was another eruption; the lava stream reached the sea in eight days, running out on the shore at a red heat, having flowed for about thirty miles under the cover of its crusted surface. Loud explosions were heard all night long like the discharge of heavy cannon, and the light was so brilliant that fine print could be read at night thirty-five miles away.

During the eruption of 1868, the outburst was accompanied by violent and destructive earthquakes. At the great fissure from which the lava burst, large stones and rocks, some of about 100 tons weight, were thrown into the air.

In 1880 the movement of the front of the stream was unusually rapid, being sometimes as much as 75 feet an hour. Altogether there have been eight eruptions of Mount Loa since 1843.

From the great volcano of Mount Loa we must now turn to the wonderful volcanic plain of Kilauea, situated on its south-eastern slope. It is a depression of about $2\frac{3}{4}$ miles long by 2 miles wide, with nearly vertical sides, rising 300 to 450 feet above the level of the crater-plain. It appears to have been formed at a time of greater volcanic activity than at present, as the recorded eruptions have been confined to the lava lake of Halema'uma'u, about 430 feet in diameter, which lies in the great plain near its south-western extremity. Traditions gathered from the natives by the Rev. J. Dibble, nearly fifty years ago, record a great eruption about the year 1789, when the whole plain of Kilauea appears to have been in action, and stones, sand, and scoria were thrown to a great height, falling in a destructive shower for many miles round. The stones are found forming a deposit of 25 to 30 feet thick over an area extending ten miles or more from the crater. Many are of great size, and their solid character makes it probable that they were torn by the ascending lava from the deep-seated rocks along the conduit of the volcano. It appears to have been a *projectile* eruption, such as has not been known in more recent times.

In the sixty-three years from 1823 to 1886, there have been at least eight eruptions of Kilauea, four of them of great magnitude. They have been characterised by violent boiling of the lava in the lake, and the rising of numerous cones in and around it, ejecting steam, vapours, and fluid lava. The fountains of lava seldom exceed 50 feet in height, but there have sometimes been as many as fifty cones in various parts of the floor, and the furious action of the boiling sea of lava produces an indescribably impressive effect. The cones thrown up are often re-melted by the lava around them; one large one formed on the lava lake actually floated upon its surface, becoming stranded after the eruption of 1886 by the withdrawal of the lava from beneath. The eruption of 1886 lasted only a few hours; the volcano was observed to be unusually active in the evening of March 6, but by two or three o'clock in the morning the lava had entirely disappeared from the lake. During this short time, however, the pit had been filled to the brim, pouring into an adjoining lake that had been formed by a previous eruption, and melting the intervening bridge of lava. For several days after the eruption immense masses of the surrounding cliffs fell from a height of 200 feet into the lake with a sound like thunder. The lava appeared to make its escape through subterranean channels, as there was no visible outflow.



View of the Crater of Kilauea.

The most remarkable feature in the Kilauea crater is the frequent and extensive changes of level to which its floor is subject. A lower pit of great extent, which had sunk in a few hours to a depth of 400 feet in the floor, leaving a terrace round the whole crater, was raised again to its former level in $5\frac{1}{2}$ years. In 1840 the subsidence of solid

lava through the escape of liquid matter was unequalled: an area of 12,000 by 3,000 feet sank down nearly 400 feet. The floor rises and sinks in a remarkably level manner, and it is highly probable that it is supported by the column of liquid lava beneath. When a discharge has taken place the floor falls; then slowly rises to or above its former level, continuing to rise till another eruption occurs. There is scarcely any visible outflow of lava from Kilauea, in striking contrast with the immense discharge from Mount Loa.

Volcanic action in a crater where there are liquid lavas is to a great extent a kind of boiling process, and the confined vapours of the enlarging bubbles forcing an escape, are the chief projectile agencies through which the more terrific explosive phenomena are produced, as well as the milder ones of the Kilauea type. Increased activity means an augmented and more rapid escape of vapours through the viscid lavas, and also greater heat, and extension by fusion of the liquid lavas below the surface. The cinder cones made about the vents in quieter times may be destroyed or swallowed up by the great projectile eruptions when the force from the rising vapours becomes greater than the mountain can bear. Its sides then break, the liquid lavas pour from the fissures, and the top of the cone frequently sinks into the abyss.

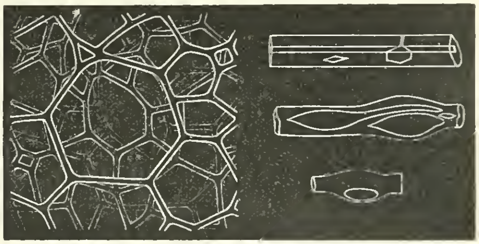
It is not our purpose to enter on the difficult question of the ultimate origin of the volcanic fires. It may be sufficient to mention the older theory of the original igneous fusion of the earth (still accepted by many geologists); and Mr. Mallet's hypothesis that the heat has been produced by lateral pressure, caused by shrinking of the earth's crust.* Whatever may be the cause of the heat, it is known that a mass at a high temperature may be kept solid by great pressure. When the pressure is relieved—either by slow denudation or by the opening of fissures—it will become liquid, and may rise to the surface. But this rise would be comparatively slow, and would certainly not cause eruptive phenomena, which it is almost certain are due to the agency of water, as was urged by G Poulett Scrope as far back as 1825.† The mode of its action has been recently discussed in an elaborate memoir by Professor J. Prestwich.‡

The slowness with which lava rises from deep-seated action alone is well shown in the case of Kilauea, where the epochs of high lava-level are separated by years. Three great eruptions in Kilauea were eight years apart, and in the interval the lift (as shown by the movement of the floor of the crater) was only 400 feet.

The sea is frequently assumed to be the source of the water of volcanoes, especially as they are commonly situated either in oceanic islands or near the seashore. We must remember, however, that this nearness to the ocean is probably in great part a result of the way in which rocks which undergo compression, so as to rise in island chains and ranges of mountains, are constantly developing new fractures parallel to their direction of upheaval. Professor Dana has pointed out that borings near the seashore generally yield fresh water, and that in Hawaii eruptions appear somewhat more frequent in the wet season. It seems probable that in this case the explosive force is caused by fresh water from the melting snows and very frequent rains, especially as the mountains are extremely cavernous and full of fissures. In the lavas of Vesuvius, however, there are salts which are probably of marine origin. The far greater eruptive force shown by Mount Loa than by Kilauea appears to result from the greater amount of snow upon the summit, as the characters of the lava are identical.

* "Roy. Soc. Phil. Trans.," vol. cxiii.
† "Considerations on Volcanoes," 1825.
‡ "Proc. Roy. Soc.," vol. xli.

In what manner does water act in producing eruptive discharges? In all probability by being introduced into the conduit of slowly rising lava. The probable processes are thus briefly summarised by Professor Dana: (1) Absorption of subterranean moisture from the sides of the conduit. (2) A rise of the lavas thus supplied. (3) After reaching a level where the pressure is sufficiently diminished, great vesiculation of the lava from the expansive force of the gases into which the water is resolved. (4) Further union of the gas particles into bubbles (where the vapours are sufficiently abundant) exerting the greater expansive force by which explosive results are produced. The great vesiculation which occurs is shown in the following figure of the lace-like scoria from Kilauea. The liquid lava when ejected is also drawn into capillary glass (called "Pele'



Enlarged Figures of Scoria Cells and "Pele's Hair" The latter contain microscopic crystals and elongated air-bubbles.

hair" by the natives), which is often formed in great abundance.

On comparing these phenomena with those shown by other volcanoes there is found a great general similarity. The volcanic processes in Vesuvius, for instance, are in the main as in Kilauea: (1) filling; (2) discharging; (3) collapsing—alternating in its conditions between a volcano with a deep crater, and one with a top plain. The crater-pit of Vesuvius is sometimes 100 feet deep; this slowly fills by small injections within it of lava and cinders. This process generally goes on (with occasional outflows from fissures in the sides of the mountain) till the cavity is full, and a top plain of solidified lavas is formed, a mile or more in circuit, and nothing is left of its crater but the vent of a cinder cone. Smaller eruptions may form a large cone or cones till a grand outburst takes place; lava fragments are thrown upwards to great heights, and lava pours from opening fissures, till the great cone collapses and falls, as in 1806, and still more in 1822. In July, 1834, the summit of Vesuvius was a plain, with a small cinder cone, but at the great eruption in August of that year the plain had disappeared, leaving a deep crater. This took place again in 1839 and 1850.

The most striking difference between Vesuvius and the Hawaiian volcanoes is the immensely greater eruptive and projectile force in the former. The Tarawera eruption in New Zealand in 1886, and that of Krakatoa in 1883, are examples of eruptions of the more explosive kind. The destructive outbreak of Tarawera lasted only six hours, but its violence was so great that dust was ejected to a height of more than 44,000 feet, and an area more than fifty miles across was buried beneath volcanic mud. At Krakatoa the discharge was equally sudden and still more terrible and destructive. Dust was thrown to a height of probably 50,000 feet at least.

What is the cause of this great difference in eruptive force? Professor Dana considers that in Krakatoa and Tarawera the water must have gained access to the *interior*

of the lava conduit, causing the terrific boiler-like explosion. In New Zealand, the water was probably that of Lake Rotomahana, which was emptied during the eruption; in Krakatoa it was doubtless from the sea.

In general the difference between a comparatively gentle eruption like those in Hawaii and these more explosive outbursts is probably caused by: (1) The difference between the viscosity of the lavas. (2) The height and strength of the cone. (3) The greater or less abundance of the water supply.

The lavas of Hawaii are remarkably glassy and fluid; while those of Vesuvius are much more infusible and viscid. With regard to the second point it is evident that the strength of the mountain may be caused by its *form* or its *material*. Fissures open with comparative ease on Mount Loa, though its slope is much less steep than that of many volcanoes; its material is mainly basaltic, and to this its weakness is due. When a mountain is of great strength it is clear that much greater resistance is offered to the forces within, and when this is the case the eruption, when it does occur, will be more violent. With regard to the supply of water, it is probably far more scanty in Mount Loa than was the case at Krakatoa or Tarawera. In Vesuvius it is mainly the greater viscosity of the lava, causing greater resistance to the explosive force, that produces the violent projectile discharges from the summit. In Mount Loa the eruption frequently commences by activity in the summit crater, but this ceases when the pressure is relieved by the opening of fissures lower down.

The variety in the nature of volcanic products may evidently be caused by the different heights to which they are ejected, as well as by different rock material. At Kilauea, where the ejections seldom reach a greater height than 50 or 60 feet, the lava falls in a still fused state, while in volcanoes whose eruptions are more explosive it is cooled into scoria, pumice, or cinders. If the explosive force is very great, as at Krakatoa, the lava is blown into enormous bubbles, whose fragments are carried to immense heights. Where the water supply is very abundant mud is discharged, as at Tarawera.

It is remarkable that although Mount Loa and Kilauea are so near together, they appear to be quite independent, and there is no correspondence between their eruptions. Professor Dana considers that they support his conclusion, expressed many years ago, that volcanoes are no *safety-valves*, for, "if, while Kilauea is open on the flanks of Mount Loa, lavas still rise and are poured out at an elevation of 10,000 feet above it, Kilauea is no safety-valve, even for the area covered by the single mountain."

NITRATES.

By D. A. LOUIS, F.I.C., *formerly Assistant Chemist in the Rothamsted Laboratory of Sir John Lawes.*

A GOOD deal of public interest has recently been aroused with respect to the large deposits of nitrates found on the coast of Chili, and to their use in agriculture. The necessity for high farming in England and on the Continent, and the consequently large amount of produce taken off the land, calls nowadays for a correspondingly high return to the land of valuable constituents in the form of fertilisers, of which nitrates are perhaps the most important.

The class of substances known as nitrates are, chemically considered, compounds of nitric acid, which itself is a compound consisting of the three elements—hydrogen (H), oxygen (O), and nitrogen (N), combined in such proportions that every 100 pounds of nitric acid contains $1\frac{3}{5}$ pound of hydrogen, $22\frac{1}{5}$ pounds of nitrogen, and $76\frac{1}{5}$ pounds of oxygen. It is represented in chemical symbols by the formula HNO_3. When this acid comes in contact with a base such as a metallic oxide, the hydrogen and the metal change places, with the result that an oxide of hydrogen (water —H_2O) and a compound of the metal with the nitrogen and oxygen of the nitric acid are formed, the latter compound being a nitrate. Such a change may be represented in the following manner:—

$$\underset{\text{Sodium oxide}}{Na_2O} + \underset{\text{Nitric acid}}{2HNO_3} = \underset{\text{Sodium nitrate}}{2NaNO_3} + \underset{\text{Hydrogen oxide (water)}}{H_2O}$$

Nitrates are also formed by the action of nitric acid on many metals and on metallic carbonates.

Many nitrates are substances with which everybody is more or less familiar. Such, for instance, are:—Silver nitrate ($AgNO_3$), the lunar caustic used by surgeons; strontium nitrate ($Sr(NO_3)_2$), used in pyrotechnical displays for the production of red flame; potassium nitrate (KNO_3), known also as saltpetre and nitre, used in the manufacture of gunpowder, of which it constitutes 75 per cent.; there is also sodium nitrate ($NaNO_3$), or Chili saltpetre (otherwise known as cubic nitre, or nitrate of soda), the valuable constituent of the "nitrate" we hear so much about just now in connection with the western coast of South America, where there are enormous accumulations of it in the neighbourhoods of Tarapaca in Chili and Atacama in Peru.

Nitrates are frequently found in nature in other parts of the globe, more especially in India, but also in Arabia, Persia, Spain, and Hungary, and in small quantities they are present in almost all soils. They originate from decaying organic matter containing nitrogen; plants die, leaving their roots to rot in the ground whilst their stalks and leaves fall on the surface and suffer decay. Moreover, in all parts of the world, animal deposits of various sorts accumulate and suffer decomposition; whenever such decay takes place in the presence of air and of some base or bases in course of time the nitrogen of the vegetable or animal matter is converted into nitric acid, which forms nitrates with the base or bases; in some soils these changes take place with great rapidity. In various parts of Europe similar changes are produced artificially. Heaps are constructed of waste and decomposing vegetable and animal matter mixed with cinders, chalk, marl, &c., which are watered with animal liquors, and after a year or two large quantities of calcium nitrate are extracted from them.

Scientific investigations have shown conclusively that these important changes are the result of the vital activity of minute organisms whose appearance has, up to the present time, not been described by investigators so as to admit of their detection by the eye; either they are too small or too transparent to be seen with the microscope, or for some other reason they are not discernible. They, however, must exist in their myriads in the air, and are still more abundant in the upper layers of the soil. These little organisms have apparently their likes and dislikes, for they thrive vigorously in warm places, where there is sufficient moisture and plenty of bases, nutritious matter, air, and material to work on; on the other hand, they perish in the cold, and in the presence of many poisonous substances, such as corrosive sublimate, and they work badly in the light. But where conditions are favourable, or have been favourable to the existence of these little microbes, we find plenty of nitrates.

In those parts of India where the soil is light, and contains

a large proportion of chalky matter, and is rich in the remains of luxuriant vegetation, these nitrates are produced in abundance, and the soil near the surface is full of them. Frequently deposits of nitre are found in those places, looking like hoar frost on the surface of the ground. In Chili similar conditions have existed, and the deposits being near the coast, it is probable that they are largely derived from animal matter, most probably marine animals and birds; in fact, remains of ancient shells indicate that the sea was there in days gone by, although the deposits are now much above the sea-level. Even in England, where the climatic conditions are such that the little organisms cannot thrive so as to work with vigour all the year round, yet on a good arable soil the amount of organic nitrogen converted into nitric acid or nitrates during a year of fallow in a good season may be put down at near 100 pounds of nitrogen per acre, which is equivalent to about 600 pounds of Chili saltpetre.

In order to extract the nitrates the saltpetre-earth is soaked in water; the resulting liquid contains all the nitrates mixed with various other soluble constituents. In Chili this liquid is evaporated down; it then deposits an impure sodium nitrate mixed with varying, and frequently very large, percentages of sodium chloride (common salt) and sodium sulphate, and with smaller quantities of calcium and magnesium salts. This impure nitrate, known as crude nitre or "caliche," is refined by repeatedly redissolving in water and allowing it to crystallise, but a little common salt generally remains attached to the crystals of cubic nitre, so that the sodium nitrate of commerce as a rule retains about 2 per cent. of salt. In India and elsewhere two kinds of saltpetre-earth exist: 1. Earth rich in potash, which is treated in the manner just described, and yields impure potassium nitrate. 2. Earth containing only small quantities of potash, but much lime and magnesia; when this is treated with water the corresponding nitrates pass into solution, and the liquid is therefore mixed with crude potash (wood-ashes, containing a large proportion of potassium carbonate), or the earth is mixed with wood-ashes before being soaked in water. The resulting liquid then leaves on evaporation impure potassium nitrate. Impure potassium nitrate, crude saltpetre, or "grough," contains potassium and sodium chorides, sometimes in large quantities, and organic matter. It is refined very much in the same manner as the Chili saltpetre.

Pure potassium nitrate forms long six-sided clear crystals, which fuse readily, and, if not heated to a red heat, leave on cooling a white opaque fibrous mass known as sal prunella. Pure sodium nitrate forms crystals which look like cubes, hence it is sometimes called cubic nitre. Both nitres give up oxygen on heating to redness, and both, especially potassium nitrate, cause rapid combustion in contact with hot combustibles, and also with many metals. It is on account of its comparatively moderate activity in such combustion, and a tendency to absorb moisture from the air, that sodium nitrate is unfit for the manufacture of gunpowder, for which purpose such large quantities of potassium nitrate are utilised. Sodium nitrate is, however, employed in agriculture, for the preparation of potassium nitrate, for the production of nitric acid, and in the manufacture of sulphuric acid (oil of vitriol).

Its employment in agriculture is, without doubt, the most important industrial application of nitrate of soda. It is a well-known fact that plants, like animals, require considerable quantities of nitrogen for their proper development, and therefore, if plants are to develop well, the soil must contain this necessary constituent, not only in a form suitable for plants to assimilate, but also in sufficient quantities to supply their requirements. The following table shows what these requirements are for ordinary crops. In the first column is the name of the crop, in the second the average weight of the total crop at harvest, in the third the average amount of nitrogen contained in such a crop. The numbers are taken from Warington's "Chemistry of the Farm," and are per acre:—

Crop.	Weight of Total Crop at Harvest per Acre.	Nitrogen per Acre of Total Crop.
Wheat (30 bushels) and straw	4,958 lbs.	48 lbs.
Barley (40 bushels) and straw	4,527 ,,	48 ,,
Oats (45 bushels) and straw	4,725 ,,	55 ,,
Hay ($1\frac{1}{2}$ tons)	3,360 ,,	49 ,,
Red clover hay (2 tons)	4,480 ,,	102 ,,
Beans (30 bushels) and straw	4,160 ,,	99 ,,
Turnips (17 tons) and leaves	49,504 ,,	112 ,,
Swedes (14 tons) and leaves	36,064 ,,	102 ,,
Mangels (22 tons) and leaves	67,513 ,,	147 ,,
Potatoes (6 tons) and leaves	17,714 ,,	67 ,,

These numbers demonstrate what large quantities of nitrogen the various crops remove from the soil, whilst the following table, compiled from various papers by Sir John Lawes and Dr. Gilbert, referring to results obtained on the clay soil of the Rothamsted Farm, shows the effect of trying to grow crops with and without nitrogenous manure on a soil impoverished by the growth of previous crops, and consequently poor in nitrogen:—

Crops.	Grown on same Soil.	
	When poor in Nitrogen.	When Manured with Nitrogenous Manures and therefore rich in Nitrogen.
Wheat	2,090 lbs.	6,982 lbs.
Barley	2,454 ,,	6,443 ,,
Hay	2,535 ,,	6,993 ,,
Potatoes	4,452 ,,	17,192 ,,
Turnips	3,024 ,,	22,960 ,,
Mangels	11,312 ,,	69,104 ,,
Sugar-beet	14,448 ,,	80,528 ,,

The first table shows the requirements of various crops, the second illustrates the advantage derived by the employment of nitrogenous manures. Although, on most farms, much nitrogen is generally returned to the soil as farmyard manure, there is even then a large deficit which has to be made up by the application of artificial manures, and for this purpose many substances are sold; but, of all of them, nitrate of soda and ammonium salts are the best, for the simple reason that the others have generally to go through a preliminary period of change before all their nitrogen becomes available for plant nutriment, whereas the nitrogen of nitrate of soda is quite ready for the immediate use of the plant; and ammoniacal nitrogen, if not already available, very rapidly becomes so.

The results of numerous comparative experiments indicate that, on the whole, nitrate of soda is superior to the ammonium salts as a source of nitrogen for plants, but, excellent manure as it is, its use can become otherwise than beneficial if it be injudiciously applied.

Pure nitrate of soda contains in every 100 lbs. about 27 lbs. of sodium, $16\frac{1}{2}$ lbs. of nitrogen, and $56\frac{1}{2}$ lbs. of oxygen; but owing to the impurities the nitrate of soda of commerce has only about $15\frac{1}{2}$ lbs. of nitrogen. The nitrogen is the active constituent, and the only one that needs to be taken into consideration when calculating quantities required as dressings for crops. Nitrate should be used only in such quantity as we know by experience is sufficient to supply enough nitrogen for a profitable increase of crop, any further addition being money

thrown away. It should not be used on light porous soils in districts where much rain is expected. It should as a rule only be applied where living plants already exist to make immediate use of the nitrogen; hence it forms an excellent material for top dressings in the spring. It is very soluble, and rain is required to make it sink into the ground and cause it to come in contact with the roots of the plants it is intended to nourish. On the other hand, too much rain would cause it to sink in the soil beyond the range of the roots, and hence become useless to the plants. This is the great cause of loss in connection with the use of nitrate of soda, and for this reason much more than the theoretical quantity of nitrate has to be employed for manuring crops. According to our first table, 100 lbs. of nitrate of soda ought to produce about 1,500 lbs. of wheat crop, but in practice only about 15 to 20 per cent. of the nitrogen applied in this manner is recovered in the crop. Therefore the resulting increase is correspondingly smaller, being nearer 250 lbs. than 1,500 lbs. Both grain and root crops are benefited by applications of nitrate of soda, and there is little doubt but the largest quantities will find their way to those countries where many acres of beet are grown for the production of sugar.

Plants dressed with nitrogenous manures always look much greener than plants grown without a good supply of nitrogen; intense greenness does not, however, necessarily indicate heavy or good crops—in fact, such a condition is more frequently the result of a deficiency of other plant foods in the soil; and although much chlorophyll accumulates, the plants, owing to imperfect nutrition, are not able to transform it into useful material such as starch and sugar; consequently such plants rarely mature properly. It must, therefore, be remembered that nitrogenous manures alone will not insure a good crop, unless all the mineral constituents required by the plants are also present in abundance in the soil; failing this condition the application of nitrogenous manure may be attended with loss instead of profit.

THE SHO-BANDAI-SAN ERUPTION.

THE eruption which destroyed the peak of Sho-Bandai-san in Japan on July 15 last is, next to the Krakatoa eruption, the most gigantic and disastrous volcanic disturbance of modern times. Sho-Bandai-san is, or rather was, one of a group of four conical mountains known collectively as Bandai-san, forming the walls of an old elevated crater basin, and rising to a height of some 6,000 feet above the sea-level. Stratified volcanic rocks, of the most part gneiss and andesite, constitute the greater portion of this mountain mass, and are mainly disposed in six great layers, the work of as many successive eruptions, the last of which took place, according to Japanese annals, 1,081 years ago. It had thus come to be regarded as an almost harmless, if not an extinct volcano, an idea that was, however, ruthlessly dispelled by the violent and destructive outbreak of July 15. On the morning of that day, after a slight preliminary earthquake shock, there came a shock of prolonged and fearful intensity. Then while the ground in the whole region was still heaving and groaning, and causing the houses to rock like ships at sea, a dense black column of débris, mud, and steam was shot forth from Sho-Bandai-san to a height of about 4,000 feet. During the next minute there were several repetitions of this phenomenon, all accompanied by loud explosions, and flashes of lightning, probably resulting from the electricity generated by the steam, shot forth from the ascending columns. In the meantime the lighter particles of the black columns, consisting of mingled steam and dust, reached an altitude of 12,000 or 15,000 feet above the summit of the mountain, and spread out into a vast flat cloud, which, until dispersed by the wind, enveloped the earth beneath it in the densest darkness. From this cloud descended a shower of volcanic dust granules, small masses, grayish in colour, which fell on the surrounding country in a scalding rain, causing dreadful injuries to people, and clothing the ground with a hot mantle on which it was painful and difficult to walk. This dust covered a land area of 1,040 square miles, and spread itself out in a fan shape, and at the Pacific shore, a distance of sixty-two miles, it had a breadth of forty-one miles. The noises of the explosions were of such intensity as to be plainly heard for a distance of sixty-two miles.

The amount of the ejecta may be judged from the fact that twenty-seven square miles of country were buried beneath volcanic débris, having over that area an average thickness of 57 feet. The matter distributed over the country by this eruption has been estimated to be equal in weight to 2,880 millions of tons.

B. J. H

PENSION TO MRS. R. A. PROCTOR.

Readers of KNOWLEDGE will have heard with sincere pleasure that the Queen has been pleased to grant a civil list pension of 100*l.* a year to the widow of the late R. A. Proctor. Amongst the signatures to the Memorial to the First Lord of the Treasury recommending the grant were the names of—

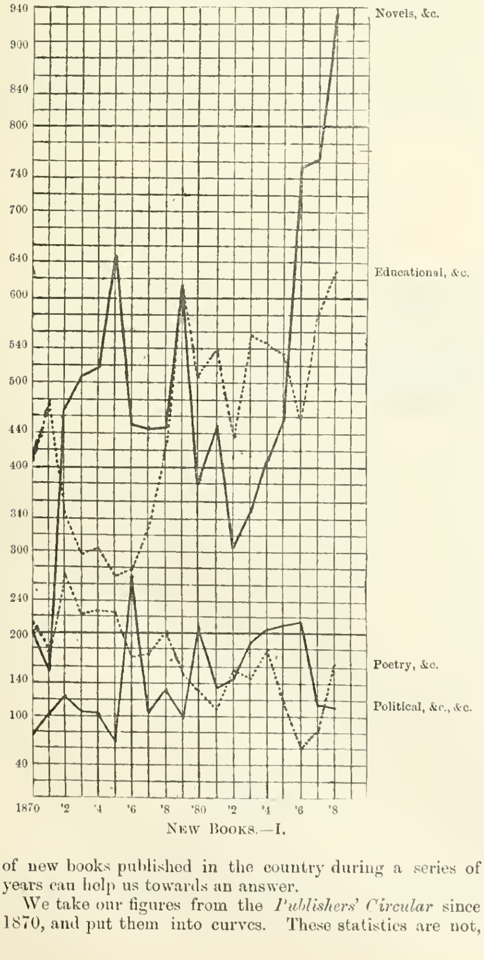
WM. HUGGINS (late President Royal Astro. Soc.).
JOHN TYNDALL.
T. W. HUXLEY (late President of the Royal Soc.).
W. MATTIEU WILLIAMS.
HERBERT SADLER.
G. L. TUPMAN, Col. R.A. (Secretary Royal Astro. Soc.).
WARREN DE LA RUE, F.R.S. (late President Royal Astro. Soc.).
WILLIAM LANT CARPENTER.
SIR HENRY ROSCOE (late President of the Brit. Assoc.).
C. J. LONGMAN (Messrs. Longmans & Co.).
GRANT ALLEN.
EDW. CLODD.
SIR JOHN LUBBOCK, Bart., M.P. (late President Brit. Assoc.)
CLEMENTS R. MARKHAM, C.B., F.R.S.
SPOTTISWOODE & CO.
SIR ROBERT BALL (Royal Astronomer, Ireland).
C. PIAZZI SMYTH (late Astronomer Royal, Scotland).
EVAN HARTNUP, Liverpool Observatory.
A. NORMAN TATE, F.S.C., F.C.S., F.G.S., &c.
KEGAN PAUL, TRENCH & CO.
J. HERSCHEL, Colonel R.E., D.C.L.
A. S. HERSCHEL (Prof. Durham Coll. of Science).
W. H. ALLEN & CO.
LORD GRIMTHORPE.
The EARL OF CRAWFORD (late President Royal Astro. Soc.).
RALPH COPELAND (Astronomer Royal for Scotland)
SIR F. L. MCCLINTOCK, Admiral.
ANDREW LANG.
The DUKE OF ARGYLL.
The MARQUIS OF LORNE.
The LORD ASHBURTON.
The DUKE OF NORTHUMBERLAND.
LORD BALFOUR OF BURLEIGH.
LORD MONCRIEFF.
JOHN INGLIS, Lord Justice General of Scotland.
A. RUTHERFORD CLARK, Judge, Court of Sessions, Scotland.
The LORD BISHOP OF LONDON.
The LORD BISHOP OF CHESTER.
R. BROCKLEBANK, D.L., Lancashire.
VERNEY LOVETT CAMERON, C.B., D.C.L.
LORD RANDOLPH CHURCHILL.
SIR RICHARD TEMPLE, Bart., M.P.
COLONEL E. B. MALLESON.
SIR O. T. BURNE
SIR GEO. BIRDWOOD.
ROBERT HAY MURRAY.
EDWIN CLARK.
COL. THOS. A. WETHERED.
C. S. MORDAUNT.
EVELYN HAY MURRAY.
J. F. CLERK.
CHATTO & WINDUS.
JOHN EVANS (Treasurer Royal Soc.).
SIR PENROSE G. JULYAN, K.C.M.G., C.B.
SIR W. HART DYKE, Bart., M.P.
R. RICHARDSON GARDNER, M.P.
HY. J. ATKINSON, M.P.
WM. FREDK. LAWRENCE, M.P., Liverpool.
ALFRED AUSTIN.
J. W. COMYNS CARR.
RICHARD MORRIS.
A. EGERTON LEIGH.
EDWARD G. MULLINS.
EDWARD STUBBS, Captain R.N.

ON CHANGES OF PUBLIC TASTE IN LITERATURE.

By Alex. B. MacDowall, M.A.

It has been well remarked by an eminent living writer that the solidity and value of a person's life depend to a considerable extent on what he reads. On the other hand, a good deal may be learnt about a person from his choice of literature. A certain correspondence between what people read and what they are is often apparent in every-day life; and the literature of a nation at any given time is an instructive revelation of national tendencies.

How are we to characterise the literature that is being so profusely produced in this our time? What can we know of the various currents in this ocean of books—their origin, their force, their direction? Let us see how far the statistics

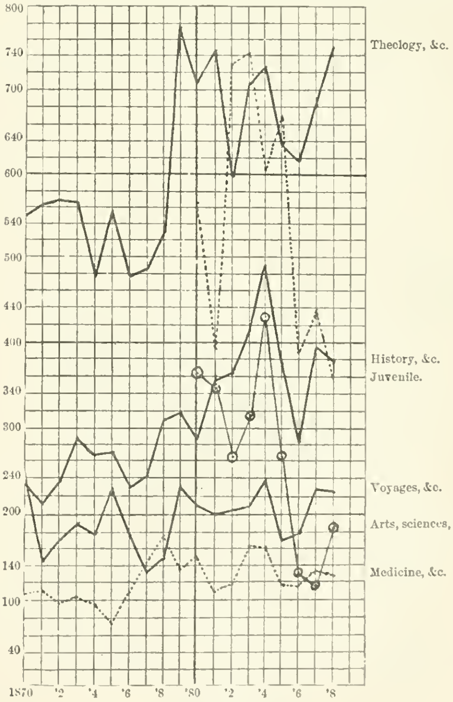


New Books.—I.

of new books published in the country during a series of years can help us towards an answer.

We take our figures from the *Publishers' Circular* since 1870, and put them into curves. These statistics are not, we suppose, absolutely exhaustive, but they probably include all books that can properly be said to be *published*. Classification of books is a very difficult matter (as anyone will tell us who has had to do with it), and some fault might perhaps be found with the system before us. But a uniform method has, we understand, been followed throughout those years. (Of the fourteen classes we give curves for ten only.)

The first thing that will probably strike one on looking at these curves, is the enormous and irregular growth of "Novels, Tales, and other Fiction" from 200 in 1870 to 929 last year. Thus we find that last year on an average about $2\frac{1}{2}$ novels appeared daily! The curve of "Juvenile Works and Tales" (of which we give only a part in II.) seems to vary generally in an opposite sense, and as it must often be difficult to say whether a book should be classed as "juvenile," we might do well to see what a combination of the two classes would yield. We get thus a rapid and more regular growth of this kind of literature from 686 to 1,286, *i.e.* nearly 100 per cent. in eighteen years. These figures probably mean at once much unhealthy reading, and an immense amount of misdirected energy on the part of authors (as it cannot be doubted that the supply



New Books.—II.

is greatly in excess of the demand, large and growing though the demand is, owing perhaps to the growing tension of modern life). In no class so much as in fiction, we suppose, are so many books read that had better be left unread; and the second-hand bookstall is eloquent about three-volume novelists and their extinguished hopes!

The next place to fiction is taken by "Theology, Sermons, Biblical," &c., the number for last year being 748, and

200 above that for 1870. Note the sudden rise to 775 in 1879. The class "Educational, Classical, and Philological," yields a very similar kind of curve, reaching 630 last year.

We may next look at "Poetry and the Drama." The curve for this seems to tend, on the whole, distinctly downwards, though a marked rise appears in the last two years; from 272 in 1872 the numbers fell to 60 in 1886. These figures, of course, give quantity only, and tell us nothing of quality. But the influences of the age are somewhat adverse, it is to be feared, to the nurture of the finer forms of poetry; and the rare plant appears to be drooping at present. When Tennyson and Browning have left us, who are likely to fill their place?

Again, the generally upward course of the curve of "History and Biography" may be pointed out; the increase of late is probably much more in biographical than in historical works. The somewhat unsatisfactory class of "Arts, Sciences, and Illustrated Works," after some large fluctuations, was last year not far from its position in 1870. The curve of "Voyages, Travels, and Geographical Research" keeps much about a level; nor is there any pronounced tendency in the curves of "Political and Social Economy, Trade and Commerce," and of "Medicine, Surgery," &c.

Of the remaining classes (not shown in diagram) "Year Books and Serials in volumes" numbered 313 in 1870, and 324 in 1888; "Belles Lettres, Essays, Monographs," &c. 155 and 165; "Law, Jurisprudence," &c., 64 and 115; and "Miscellaneous, including Pamphlets not Sermons," 125 and 507.

Taking the total of new books, we find a fluctuating rise from 3,377 in 1870 to 4,960 last year, or about 48 per cent. The population increased, during this period, about 20 per cent. "New editions" (which we have not here considered) would increase the above totals by, roughly, one-third in each year.

The explanation of these fluctuations in the total, and in each class, is not very easy. The state of trade in general has probably something to do with them, but anomalies arise when we compare with a trade-curve. The great law

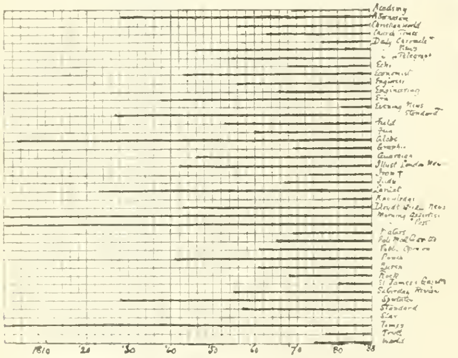


DIAGRAM SHOWING THE AGE OF THE PRINCIPAL PAPERS AND PERIODICALS.
The *Morning Post* dates from 1772; the *Times* from 1788; *Morning Advertiser*, 1794.

of rhythm may perhaps be discerned in book production; books of a given class are published in increasing numbers till the thing is found to be overdone, and there is a swing of the pendulum to the other side. Then there is the enormous growth of newspaper and periodical literature; and this, with its variations, must influence the annual crop of books.

As illustrating this remarkable growth, we add a diagram which shows, in a simple way, the ages of some forty well-known papers. It will be readily seen how young, on the whole, is this development; very few papers, indeed, reaching back to the earlier parts of the century.

NEWSPAPER STATISTICS.

From the "Newspaper Press Directory for 1889" we learn that "there are now published in the United Kingdom 2,176 newspapers, distributed as follows:—England:—London, 463; provinces, 1,277—total 1,740; Wales, 87; Scotland, 190; Ireland, 146; and Isles, 23. Of these there are 133 daily papers published in England, 6 in Wales, 19 in Scotland, 15 in Ireland, and 1 in British Isles. On reference to the first edition of the "Newspaper Press Directory" for the year 1846, we find that in that year there were published in the United Kingdom 551 journals; of these 14 were issued daily—viz., 12 in England and 2 in Ireland; but in 1889 there are now established and circulated 2,176 papers, of which no less than 174 are issued daily, showing that the press of the country has nearly quadrupled during the last forty-three years. The increase in daily papers has been still more remarkable—the daily issues standing as 174 against 14 in 1846. The magazines now in course of publication, including the quarterly reviews, number 1,593."

VARIABLE STARS IN NEBULÆ AND NEBULOUS VARIABLES.

By HERBERT SADLER, F.R.A.S.

MR. PEEK'S observations of the variable S Coronæ having either been hid by nebulosity, or having apparently turned into a nebula, are very interesting and remarkable. In the case of this very star, Schmidt of Athens observed on one occasion that for several days before S became visible the place where it should have been seen appeared to be nebulous, and that then S became slowly recognisable. Tempel remarked the same nebulous glimmer about several variable stars, amongst them one of Goldschmidt's, which wholly disappears. One of the most remarkable instances is that of T Tauri. The nebula touching this star was found on the morning of October 11, 1852, in one of the finest skies ever experienced by Mr. Hind at Mr. Bishop's observatory in the Regent's Park, being at once caught in slow sweeping with the 7-inch refractor. A star of the 10th magnitude nearly touched the nebula on the *s.p.* side, and this star was subsequently found to be variable by Hind, being called T Tauri. In 1861 the nebula had completely vanished, though traces of it appear to have been seen by O. Struve at Pulkowa in 1862. But in 1863 and 1876 the nebula was looked for with the same telescopes and eye-piece with which it was first discovered, yet no trace of it was to be found. There appear to be several faint nebulæ about here, and the place should be carefully photographed. Dreyer could see no nebulosity round T with Lord Rosse's 6-foot reflector in 1877. The period of this variable star, T Tauri, touching the nebula, has, I believe, never been determined. Mr. Ingall informs me that with the 10-inch dialyte constructed by himself he saw on February 1 of the present year T Tauri very faint, about 14th magnitude, and faintly nebulous, and on February 6 he again saw a faint nebula

THE CORONA *of 1st January, 1889.*
From a Photograph by PROFESSOR BARNARD.

Rough Drawing of the same CORONA.
Made from Photographic Transparencies.

From a Drawing by MISS M. L. TODD

round the variable. This variable star, R Coronæ Australis, is also situated in a small nebula, and the nebula is variable also. Moreover, there is another variable star, S Coronæ Australis, and two other nebulæ within 5′ or 6′ of arc of this one. U Geminorum, a very remarkable variable, with an irregular period (it once increased three magnitudes in 24 hours), was observed by Baxendell to be nebulous at maximum. A star near Nova Vulpeculæ of 1670, within 1′ of arc of its calculated place, was observed to be nebulous or ill-defined by Hind, Talmage, and Baxendell. Of η Argus, Nova Cygni 1876, and Nova Andromedæ 1885, there is no need to speak. T Scorpii was situated apparently not in a nebula (for M 80 Scorpii, though often called a *nebula*, is really a very condensed cluster of small stars); but nevertheless, its probable association with the cluster, and the fact that there are at least two well-recognised and one or two suspected variable stars in the same field of view, is worthy of notice. The variability of at least a dozen small stars in or near the trapezium in the great nebula of Orion, and of certain parts of the nebula itself, is more than suspected, while Nos. 654, 709, and 822 of Bond's "Catalogue of Stars in the Nebula" are recognised variables.

THE TOTAL SOLAR ECLIPSE OF 1889, JANUARY 1.

By A. C. Ranyard.

A GREAT number of American astronomers, both amateur and professional, journeyed to the State of California to place themselves on the first of January of this year within the path swept out by the moon's total shadow. Within this narrow track of shadow during the minute that the total eclipse lasted observers were able to see the faint objects in the sun's neighbourhood which are usually hidden from our sight by the dust and small light-dispersing particles which float in the earth's atmosphere. Under ordinary circumstances this dust is so brightly illuminated by the sun's light that it blots out the stars and the faint light of the solar corona as if a veil were drawn across the heavens—a veil not thick enough to be opaque, but through which only brighter objects can be seen, the sun quite clearly, the midday moon subdued in light, and very occasionally a brilliant comet, and Venus at her brightest; but otherwise the blue veil of sky light with which everyone is so familiar blots out, or rather drowns with its own brightness, the fainter light of the stars and milky way, which shine behind it just as steadily as at night.

During the precious moments of totality the direct light of the sun, which ordinarily illuminates this blue curtain, is cut off by the body of the moon, and the dust-veil becomes transparent, so that for a few moments we can look through it and see the comparatively faint objects about the sun, which, one need hardly explain, can never be studied at night, as they rise and set with the sun.

During the darkest total eclipse a little light finds its way from objects on the horizon, outside the shadow area, to the dust floating in the air within the moon's shadow; and even this light is sufficient to faintly illuminate the dust-veil, so that it blots out most stars below the third magnitude, though sharp eyes have occasionally seen stars of the fourth magnitude when the observer knew just where to look for them; but we may be sure that it is only the brighter surroundings of the sun that become visible to our eyes during the darkest eclipse, or that leave their trace upon the photographic plates exposed during totality—nothing so faint as the milky way could possibly be seen.

On the opposite page, at the top left hand side, is a photographic reproduction from a paper copy of the corona kindly sent me by Mr. Burnham, of the Lick Observatory. Below is a photographic reproduction of a drawing by Miss Mabel Loomis Todd, kindly sent me by Professor Todd, of Amherst College Observatory, who is well known as an enthusiastic student of eclipse phenomena. At the top right hand side is a photograph from a sketch made from some glass positives of the same corona which have been sent to England.

The eclipse took place at a time when there were but few sun-spots, and the corona observed has the marked characteristics of a sun-spot minimum corona. The polar streamers curve away uniformly from either pole, and the equatorial extension is considerable. The equatorial groups of structure are bounded by rays which are greatly inclined to the radial line drawn from the sun's centre to the region of the limb from which they spring.

In comparing the lower drawing with the upper pictures of this corona, it should be remembered that Miss Todd's drawing has not been turned so as to bring the sun's axis vertical on the page with the north point uppermost. When this is done the correspondence between the drawing and the photographs can at once be traced. This drawing and the paper photograph here reproduced do not show the rays and brighter coronal structures visible on the glass photographs within the coronal area, but enough has already come to England to show that a very fine series of photographs showing a great deal of structure has been obtained during this eclipse. We look forward with much interest to the series of comparatively large coronal photographs taken with the large object-glass of Professor W. H. Pickering, who was stationed at Willow, California.

DRIFTING SAND.

By Cecil Carus-Wilson, F.G.S.

IN walking along a sandy beach on a windy day we may see vast quantities of dry sand blown continually in one direction. In consequence of sand being blown thus in the direction of the prevailing wind, accumulations called *dunes* are formed, and these hillocks of drifted sand form interesting objects of study on various parts of our coast, as they are continually advancing, dispersing, or changing their forms.

On the north-western coast of Cornwall large sand drifts occur, and have overwhelmed an old Constantine chapel, the ruins of which may still be seen; some of these sand-hills reach a height of more than 300 feet. But our British sand-hills are insignificant when compared with the Hurku Hills in the Gobi Desert; these gigantic sand-drifts extend forty miles in length, and reach in some places an altitude of 900 feet, having been formed by the action of the wind upon the sand of the desert.

Sand dunes travel in the direction of the prevailing winds, and if precautions are not taken they continue to advance inland and overwhelm everything they encounter, even streams occasionally failing to arrest their progress. In Norfolk buildings have been buried, in Scotland vast tracts of fertile land have been turned into barren wastes, and in Ireland the ancient town of Bannow has disappeared beneath the advancing sand-drift.

Some years ago, on the coast of Crozon, near Brest, a large hill of sand was removed by a gale, and the remains of a village with a church and churchyard exposed to view;

how long this village had been buried no one knew, as no records could anywhere be found to throw light upon the subject. The existence of buried cities beneath the sands of Egypt is well known, parts of the higher buildings rising like monuments above the desert to mark the tombs beneath.

On the shores of the Bay of Biscay the drifting sand travels inland at a rate of about 16 feet in a year, while in some parts of Denmark the rate of encroachment reaches 24 feet in the same time. A survey made some years ago in Southern India showed that the movement of sand hills with the prevailing wind reached the high average of 17 yards per annum.

The advance of drifting sand may sometimes be checked by planting the dunes with the cluster pine, sand marram, &c.; these form a network of rootlets binding the sand together, which, with their protective covering of vegetation, prevents further drifting. Sir Wyville Thomson gives a graphic account of the celebrated "sand glacier" at Elbow Bay, in the Bermudas; it is a dune of pure white coral sand, which has filled a valley, and is slowly advancing inland in a mass 25 feet thick; it threatens to overwhelm cottages and woods, and could only be arrested by the planting of the native juniper and oleander. Many instances occur in the Bermudas of houses and woods being buried beneath these coral sand dunes.

Occasionally, blown sand is mixed with fragments of shells or other calcareous particles. Rain-water holding carbonic acid in solution may then dissolve these fragments, and rearrange the lime as a cement, and this binds the grains together and forms a friable sandstone. Near Newquay, in Cornwall, sandstone of this recent *subaerial* formation occurs in cliffs of considerable height, and the hardest varieties have been used in the construction of Cranstock Church and many other buildings in the neighbourhood. The curious cylinders of indurated sand—"Pixie Holes"—occurring at Little Fistral, in the same neighbourhood, are the result of similar consolidation; the sand was compacted into a solid mass by means of the calcareous cement, and part of this was again subsequently removed by percolating water.

In the island of Bermudas—which is simply a large bank of drifted coral sand—the only rock occurring is "a white granular limestone" formed by the same chemical process.

On the coast of Gascony, where sand dunes extend for over a hundred miles, more elaborate means had to be adopted in order to save the land from being buried beneath the drifting sand. A wooden palisade was erected along the shore, and as the sand drifting against it accumulated and increased in height, the palisade was continually raised until it reached an altitude sufficient to bar the progress of the sand.

Drifting sand may be carried to a great height by a strong wind. In our country, during gales, when the sand is dry it may be carried up 200 feet or more; but in the sand-storms of the deserts, when "sand-spouts" occur, it probably reaches a much greater height than this. In the spring of 1882 a remarkable sand-storm raged in Iceland for two weeks. The air was so filled with grains of fine sand that it was impossible to see objects a few yards off, and though the sky was clear of clouds the sun was rarely seen. Like the fine volcanic dust that overwhelmed Pompeii, this sand penetrated through the smallest cracks and crevices, entering the houses, and becoming mixed up with the food. Thousands of sheep and horses died owing to the sand being drawn into their lungs at every inspiration.

At the late Bath meeting of the British Association, in an interesting communication by General Strachey on the "Sea Temperature in the neighbourhood of Cape Guardafui," it was shown that this cape, the most eastern point of Africa, was, owing to the large and continued increase in the number of ships frequenting the canal route, one of the most important headlands in the world. Homeward-bound vessels from the East by the canal make for Guardafui, just as ships bound for the English Channel steer for the Lizard. During the period of the south-west monsoon, and especially from June to August, the vicinity of Cape Guardafui is enshrouded in a dense haze, extending far out to sea. Now, this haze is due to the suspension in the air of great quantities of fine sand, which have been brought by the wind from the African deserts. Vessels thus have great difficulty in making the land, many are frequently lost, and the navigation of the coast is fraught with much danger through the action of wind-borne sand.

Wherever drifting sand is continually blown against hard rock it polishes the surface by its constant friction. The hard granite cliffs on the Cornish coast are polished and furrowed in this way, and the Egyptian monuments, where exposed to the sand-laden winds of the Libyan desert, present a similar polished appearance.

At the Edinburgh meeting of the British Association in 1871, Mr. Grieve described some large masses of limestone occurring on the shore near Burntisland which were polished by drifting sand, and through the means of which he discovered a new species of a coal measure fossil plant—*Dictyoxylon Grievi*—occurring in the limestone.

Many of the desert pebbles are beautifully polished, having a remarkable and characteristic varnished appearance, owing to the action of drifting sand, and the scooping out of the dry *wadys* of Palestine has been effected by the same means.

In connection with this, Mr. Blake has described the action of drifting sand in the Pass of San Bernardino, California. He says that the surface of the granite forming the projecting spurs of the mountain of San Gorgonio was beautifully grooved and polished, and long and parallel furrows were cut out by the abrading action of drifting sand. The hardest minerals present in the granite—quartz, tourmaline, and garnets—were all cut down and left with polished surfaces. An interesting fact was that some of the garnets, being harder and less easily worn than the other minerals, were left standing in relief upon long pedicles of felspar that had been more quickly worn away. On the lee side of some of these garnets the felspar was protected from the advancing sand, so that it frequently stood out in ridges to the leeward of the gems. It was easy thus to see which was the direction of the prevailing wind, and Mr. Blake says: "These little needles of felspar, tipped with garnets, stood out from the body of the rock in horizontal lines, pointing like jewelled fingers in the direction of the prevailing wind."

Pillars of Sand supporting Pebbles or Shells.

I have often observed a similar phenomenon in walking along the sands between Bournemouth and Poole Harbour; dry sand is frequently blown rapidly along the surface of the beach left wet by the retreating tide, the wet sand being usually crowded with pebbles or shells. On the higher part of the beach, where the sand is blown violently against these pebbles, &c., they resist the advancing sand and protect that on the lee side of them; the wet sand, too, behind the pebbles, owing to the protection it receives, is not dried so quickly as the surrounding sand, and the result of this action is that the pebbles and shells are left standing on

remarkable little pillars of wet sand, which increase in height as the more rapidly dried sand is blown away. The drifting sand and wind together eat out the bases of these little pillars, causing them to point in the direction of the wind; as these increase in length the weight of the suspended particles overcomes the cohesion of the wet sand, and they fall to the ground. These pillars vary from one to two or three inches in height, according to the size of the capping stone or shell. Reference to the accompanying diagram will show three stages in the growth of these pillars.

The abrading action of sand when conveyed by a current of air has been taken advantage of in the construction of the "sand-blast," in which sand is carried up a pipe terminating in a nozzle from which a jet issues with great force, and eats away any hard substance with which it comes in contact. Glass is by this means engraved, especially gas-globes, the "frosted" appearance of which is due to the impinging sand; that part of any glass article which is to remain untouched is coated with some soft, elastic substance such as glue or gelatine; into this the driven sand becomes embedded, and, consequently, has no effect on the glass. Only hard substances are abraded; the workmen can hold their hands in the jet of sand with impunity, but the nails of the fingers would very quickly be destroyed if exposed to the blast. Files are by this means cleaned of the softer metals embedded between their teeth.

The sand-blast is now brought to such a state of perfection that even the pattern of a delicate lace can be reproduced on glass, while the power of the blast is such that wood, marble, granite, and even steel can be perforated in a few minutes.

NORTH AMERICAN-INDIAN FAIRY-LORE.

By Miss Mary Proctor (Stella Occidens).

"It is well known by all Indians who still keep the faith of the olden time that there are wondrous dwellers in the lonely woods, called by the Micmacs *Mikumwessos*." They were created from the bark of an ash tree by the great Algonquin god, Glooskap, a hero who is somewhat like the Scandinavian gods Thor and Odin. His name means "the liar," because when he left the earth, like King Arthur, for Fairyland, he promised to return, and has not as yet kept his promise.

Before man was, he created the Mikumwess, or small elves, dwellers in rocks. They are fond of playing on magic flutes, and a maiden who hears the melody is bewitched with love, and if the fairies are sufficiently pleased with her, they make her a fairy like themselves. They play all day long in the woods, among the sunlight and shadows. One day when Glooskap was walking through a forest he suddenly came upon a group of these dancing elves. Their queen, Summer, was so beautiful that Glooskap caught hold of her and ran away with her in his arms as fast as he could. The fairies threw a rope after him, which coiled itself around his neck; but as he ran it unrolled, and he was soon out of sight. He took Summer to the lodge of Winter, and presently Winter melted away, and his wigwam too. "Then everything awoke; the grass grew, the fairies came out, and the snow ran down the mountain-side into the rivers, carrying away the dead autumn leaves. Then Glooskap left Summer with them and went home."*

On another occasion some of the fairies were invited to a wedding, and one of them astonished the people very much by his dancing. "As he danced around the circle upon the hard beaten floor, they saw his feet sink deeper at every step, ploughing the ground up as the dance went on, into a trench, until at length only his head was to be seen." This ended the dancing for that evening, for the ground could only be danced on after that by fairies and witches.

Sometimes mortals have married fairies, and lived with them in their forest home. If a man sees a fairy, he has but to tap her lightly on the head with a small stick, and, according to the laws of Fairyland, this makes her his wife. The custom, on being captured, is for the maiden to faint away; then she is carried off quietly to her new home. Apparently she has not much choice in the matter.

In the olden times there were two hunters, who lived by themselves in a lonely forest. When winter-time came, and their snow shoes and mocassins gave out, they wished that a woman was there to mend them. Now, by means of sorcery a bright little fairy knew their wish, and one evening, on their return from the woods, the younger brother found the wigwam cleaned and swept, a fire built, and the pot boiling for supper. The hunter did not tell his brother, and took all the credit to himself. The same thing took place next day, and the day after; the hunter watched the door from a hidden place. Presently a beautiful and graceful girl entered the wigwam, and was soon busy with the housework. The hunter walked into the hut, and the girl was at first alarmed when she saw him, but he calmed her, and they were soon the best of friends. When all the work was done, they played together, like two children, in the sunlight and shadows of the forest, for they were both young. When the sun's shadows became long, the girl said, "I must go now, I hear your brother coming, and I fear him. But I will return to-morrow. Adieu." This continued for many days, and when at last the younger brother told the older brother, he said, "Truly I should be glad to have some one here to take care of the wigwam and mend our snow-shoes." So the winter passed away very pleasantly, until summer came and melted the snow, and it was time for the hunters to return to their village.

As they approached their home the fairy left them, for she knew by sorcery that their father would not be pleased to see her. Indeed, when he heard about her, he was very angry, and said, "All my life have I feared this. Know that this woman was an imp of the woods, a witch of the Mitche-hant, a sister of the *Oonahgamess*." Then these ungrateful brothers were afraid, and went forth to slay her, and the elder brother shot an arrow at her. "Then there was a strange fluttering of scattered feathers, and they saw her fly away as a partridge." When they told their father, he said, "You did well. I know all about these female imps who seek to destroy men." Now the younger brother longed to see the fairy again. He found her in the woods, and they were soon friends again, and played together as before. And when evening came the boy said, "I must return."

"Whenever you would see me," the maiden replied, "come to the woods. And remember what I say. Do not marry any one else, for your father wishes you to do so, and he will speak of it to you, and that soon. Yet it is for your sake only that I tell you this." She told him that, if he married another, he would surely die. And all came to pass, for the father compelled his son to marry a bride from a distant land. The bride came, and for four days they feasted and held a wedding dance. But on the evening of the fourth day the bridegroom said, "This is the end of it all," and he laid him down on a white bearskin and died. Then the father left the place for ever, and wandered far away brokenhearted.

* Charles Leland, "Algonquin Legends," p. 131.

Among the Indian traditions there is one bearing a resemblance to the story of "Bluebeard." A hunter had taken under his care an elf, who was so small that he always kept him in a box. When the hunter left home he would close the lid carefully, so that the evil spirit (Mitche-hant) should not get hold of him. One day this hunter saw a very beautiful girl sitting on a rock by the river-side, so he paddled his canoe quietly towards her. However, she saw him coming, and in a moment she disappeared under the waves. Her mother, who lived among the mermaids, advised her to return to the hunter, who would treat her well if she obeyed his commands. The maiden did not find the hunter at home, but she cooked supper for him, and put his wigwam in order. The hunter was very pleased to find her on his return after a long day's hunt, and bade her cook half a beaver he had brought home. The same command was given every day, until the hunter's wife began to wonder how the other half of the beavers disappeared. She determined to watch her husband, and one night she pretended to be fast asleep, whilst she was really as wide awake as she could be. Then she saw her husband cook the other half of the beaver, and, opening a box which stood in a corner of the room, he took out the little red dwarf and fed him. He also washed him and combed his hair, and put him back in the box again. Next morning when the hunter had gone out, his wife opened the box and tried to coax the little elf out. Finally she pretended to go away, and the dwarf peeped over the top of the box to see where she had gone, when she caught hold of him, and held him tightly. But her fingers on touching him were stained red, and as she tried to comb his hair, they became redder still. To add to her terror, a fearful clap of thunder rent the air, the door flew open, and a most horrible looking being entered the room. He snatched the little man out of her hands, and vanished in a flash of lightning. However, the unhappy girl had no time to waste, for she knew her husband would wonder at the red stain on her hands, and she must wash it off before he came home. But the more she washed the brighter it became, so she resigned herself to her fate. When her husband saw her terrified face and red hands, he knew what she had done. He seized his bow to beat her, but she ran out of the wigwam, and threw herself into the river, and as she touched the water she turned into a sheldrake duck, and to this day the marks of the red stain are to be seen on her feet and feathers.

THE GREAT NEBULA IN ANDROMEDA.

ON the opposite page is a reproduction by a new process from a paper photograph enlarged about four diameters from Mr. Isaac Roberts's negative of the Andromeda Nebula taken on December 29, 1888, with an exposure of four hours. Considering the great interest attaching to this photograph, it has been thought advisable to give this reproduction by a photographic process to compare with and check the woodcut given in our last number. In order to prepare the woodcut in time for the February number, it was necessary to engrave it on a wood block which took to pieces, and could be given to two different engravers to work upon at the same time. Unfortunately the block was not put together again with sufficient care, and a white line corresponding to the division between the two parts of the block shows across a part of the middle of the page, which corresponds to nothing on the photograph. Some white dots have also been put in by the engraver to increase the brightness of the southern end of the nebula, which have come out as small stars on the woodcut, and have no existence upon the photograph. But otherwise the woodcut gives a very satisfactory representation of the original negative, except that it was impossible to show the structure in the brighter central part of the nebula, which has a stellar nucleus, and the faintest regions of nebular light. The same difficulty has to be contended with in the photographic reproduction now given, and in addition the smaller stars shown in the original negative are lost.

The illustrations of the Lick Observatory, published in the December number of Knowledge, were made by a photographic method from the excellent woodcuts of the Observatory published in *Engineering* for August 31, 1888. This and the subsequent numbers of *Engineering* contain plans to scale of the dome, with the hydraulic machinery for raising the floor, and other ingenious contrivances of Sir Howard Grubb and others, made use of in the Lick Observatory.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

VIVISECTION.

To the Editor of Knowledge.

Sir,—The inexplicable fascination supposed to be exercised by snakes over little birds seems to be exercised by Snake-poison Experiments over physiologists. Again and again warnings have been issued by eminent men of science of the utter inutility of trying to run after and overtake the venom coursing through the veins of a bitten man and then neutralising it by means of an antidote which, even if discovered, could scarcely be expected to form a Pocket Companion for the 20,000 nearly naked Hindoos who are alleged to perish annually from Snake-poison in the jungle. Such cautions are all in vain. "Hope springs eternal" in the physiological breast. Science never has, but always will, be blessed by the discovery of the grand Arcanum.

Permit me to quote the observations of Sir Joseph Fayrer, himself a vivisector and a great authority on snakes, in his presidential address before the Medical Society of London, as reported in the *British Medical Journal*. After referring to the supposed virtues of permanganate of potash, Sir Joseph said :—

> We are still, then, as far off an antidote as possible, and the remarks made by me in 1868 are as applicable now as they were then. They were as follows: To conceive of an antidote, as that term is usually understood, we must imagine a substance so subtle as to follow, overtake, and neutralise the venom in the blood; and that shall have the power of counteracting or neutralising the poisonous or deadly influence it has exerted on the vital force. Such a substance has still to be found, nor does our experience of drugs give hopeful anticipations that we shall find it.—*Brit. Med. Journal*, Feb. 2, 1884.

Dr. Lacerda, in a letter to Sir Joseph, wrote to the same purpose: "As to the idea of finding a physiological antidote for snake-poison, I entirely agree with you that *it is a Utopia*"—a remark the sense of which is plain, though the grammar is open to discussion.

Mr. A. J. Field, in his article in your issue of February 1, shows that in time the sanguine (I will not add sanguinary) spirit of modern biology overleaps such obstacles as those described by Fayrer and Lacerda. He flies straight to "Utopia" *viâ* Boulogne; happy to carry forward his researches in that "beautiful France" where

THE NEBULA IN ANDROMEDA.

From a Photographic Enlargement by MR. ISAAC ROBERTS, *of his Negative of 30th December,* 1888.

(as M. Zola would lead us to suppose) every other kind of licence prevails, but where no licence is needed for vivisection. Your readers will reflect with satisfaction that Boulogne boasts brighter attractions than that of freedom to torment animals; else they would feel that the crossing of those stormy waters of the Channel from Folkestone merely for the sake of such experiments as are described by Mr. Field in your columns, was altogether a Quixotic undertaking on the part of that knight-errant of science.

I have very little to say of Mr. Field's experiments. They were by no means specially cruel, and he expresses an amount of compassion for his little white-mouse victims, which is quite a novel feature in the reports by physiologists of their own doings. Like Walton's angler, he treats the worm he puts on the hook "an' as if he loved it." But I think that the repetition of these everlasting tricks with snakes and poisoned animals, which form the "Chamber-sport" of so many men of science, is a moral phenomenon not undeserving of notice among the morbid vagaries of the human mind. Mr. Field mentions Fontana's experiments, and I have no doubt he has seen the edition of his great work on the "Venom of the Viper," published just a century ago (1787) by the John Murray of that day, wherein the translator (a surgeon named Skinner) challenges our confidence on behalf of his author in this portentous sentence:—

> But what confidence ought not an author to inspire us with, who, after having said, "I have made more than 6,000 experiments; I have had more than 4,000 animals bit; I have employed upwards of 3,000 vipers," finds no difficulty in adding, "*I may have been mistaken, and it is almost impossible that I have not been mistaken.*"

Unless Mr. Field can flatter himself that he can greatly overpass Fontana's forty hecatombs of unhappy animals killed in this painful way, I do not see how he can flatter himself with any hopes that he also will not be "mistaken" in any discovery he may imagine himself to make. Truly Dr. Leffingwell wrote well on this whole subject of vivisectional experimentation when he said: "If animal pain could be measured by money, there is no Mining Company in the world which would sanction *prospecting in such barren regions.*"

Mr. Field thinks that "he who hinders the progress of such investigations commits a sin against mankind." I venture to assert, on the other hand, that he who, for the sake of remote and doubtful physical benefits to our race, encourages a practice which, unquestionably and immediately, must stifle the divine impulses of compassion and pity in the human soul, is the real "sinner against mankind." I have even some support for the further belief (though I attach much less importance to it) that he who opposes experimentations on animals is also a truer friend to Science than he who promotes them. Mr. Lawson Tait, one of the first surgeons of the day, concludes his powerful paper on the "Uselessness of Vivisection" by these noteworthy words:—"I hope I have made it clear that, deeply as I feel the strength of the objection to the practice of vivisection upon the various grounds indicated at the beginning of this paper, I urge against it a stronger argument—that it has proved useless and misleading, and that in the interests of true science its employment should be stopped, so that the energy and skill of scientific investigators should be directed into better and safer channels."—I am, Sir, truly yours, Frances Power Cobbe.

Hengwrt, Dolgelly: February 7.

To the Editor of Knowledge.

I have to thank the editor for giving me an opportunity of replying to Miss Cobbe's criticism on my paper in the last number. She quotes Sir Joseph Fayrer and Dr. Lacerda as if they thought it useless to experiment further, and had been converted from the errors of their ways; but neither of these vivisectors has given up vivisecting and experimenting, as we must conclude that they would have done if Miss Cobbe's interpretation of their words were correct.

The fact that an antidote has been discovered which is capable of "coursing after and neutralising" the poison of many viperine snakes renders it probable that a similar antidote may be discovered for the poison of the colubrine snakes and all the other venomous creatures which occasionally endanger the life of man.

Miss Cobbe is too impatient if she expects such discoveries to be made on the first or second experiment; our steps to higher knowledge are made very slowly—generally after repeated failures. She forgets the long series of painful deaths which have brought about each step in the survival of the fittest, and that Nature herself is far more cruel than any man of science. What student of nature is guilty of such cruelty as the Ichneumon fly, whose eggs are deposited within the body of the living victim so as not to destroy its life, and whose young, generation after generation, vivisect their hosts, carefully avoiding the vital parts?

I will not refer to the innuendoes of Miss Cobbe about "the chamber sports of so many men of science," further than to say that, as far as my experience goes, those who study animals most closely have most sympathy with them, and that those who follow most blindly what Miss Cobbe calls "the divine impulses of compassion" are answerable for a great deal of misery they do not see and do not consider. Their sympathies follow an impulse which should be controlled by thought. If sympathy is not so controlled, there is such a tendency to sympathise with the weaker, that criminals, and those who are physically unfit for the battle of life among men and the lower animals, will come in for all the sympathy and aid that had better be given to the higher organisations, which Nature will continue to select in spite of our puny efforts to interfere with her choice. Nature's way of replying to such interference is by a slower and more lingering method of extermination, which only multiplies the pain that would have originally been given. A. J. Field.

ABRAHAM SHARP'S SHORTHAND.

To the Editor of Knowledge.

Sir,—I have seen, but have not had an opportunity of examining, a specimen of Sharp's shorthand. It is questionable whether the system was an original one, as it is referred to in the following terms by the editor of Dr. Byrom's system, a work on shorthand published in 1767, after Byrom's death:—

"The first occasion of turning his attention that way [referring to Byrom's study of the art of shorthand] arose from his acquaintance with the late Mr. Sharp, at Trinity College, Cambridge. This gentleman's father, at that time Archbishop of York, had recommended to his son to make himself master of shorthand as an art very useful and commodious. Incited by an authority so respectable, the two friends [Byrom and Sharp] applied themselves *to the study of the method then in vogue;* but Mr. Byrom was so disgusted with the absurdity and awkwardness of its contrivance that he soon threw it aside."

Byrom consulted everything he could procure, in print or manuscript, on the subject of shorthand, and produced a new system which soon became famous.

My object in writing is to suggest that if a number of Sharp's shorthand memoranda, which I understand are in

existence, were to be examined by some shorthand experts, they might throw a light upon the Newton-Flamsteed controversy.—Yours, &c.,

Edward Pocknell,
Past President of the Shorthand Society.
64 Imperial Buildings, Ludgate Circus,
London, E.C.

The following letter, not written for publication, will be read with interest in connection with the above and the review of Abraham Sharp's life :—

"Dear Sir,—Referring to our conversation of yesterday respecting the system of shorthand used by Abraham Sharp, I find from my notes that the 'Sharp' with whom Byrom studied an uncouth system of shorthand then in vogue was 'Tom Sharp' (as he was familiarly called), afterwards a D.D. and Archdeacon of Northumberland. This person was a son of Archbishop Sharp, and father of the well-known Granville Sharp. On Abraham Sharp's monument he is stated to be a relative of the archbishop. Both were born in the same village. Possibly one of the old books on shorthand getting into Little Horton had become known to both of the Sharp families, and, if so, the system is probably that which set Byrom's wits to work to fashion a better and more rational one.

"When Chalmers wrote his 'Biographical Dictionary' he gave an interesting account of Abraham Sharp, and stated that a chest full of letters remained in possession of his relatives — his correspondence with Flamsteed, Newton, Halley, Wallis, and other scientific men of the day—and that on the letters his answers to his friends had been carefully copied in shorthand.

"I have a specimen of Sharp's shorthand writing on a letter dated June 1705, and I have attacked the neatly written but uncanny-looking signs, with the result that in three hours last night I mastered the alphabet and most of the symbols. In time I shall penetrate the whole mystery. At all events, I can now read two-thirds of the shorthand letter and accompanying notes. The main system of shorthand used by Sharp was one of which very little is known, but it evidently contains grafts from other systems, and spurts of the writer's own fancies have made it complex. Like all these old riddles, the solution must come at last to an expert.

"Correspondence with men like Newton and Flamsteed would contain a good many scientific phrases, but that would be no bar to decipherment.

"I will endeavour to make a complete translation of the letter and notes in the course of a few days. But in the meantime you will be justified in saying 'the nut is cracked.'—Yours faithfully, John Westby-Gibson.

"February 22, 1889."

Notices of Books.

Life and Correspondence of Abraham Sharp. By William Cudworth. (Sampson Low & Co., 1889.)—The thanks of all who are interested in the history of astronomy are due to Mr. Cudworth for the publication of this handsomely printed and illustrated volume upon which he has evidently bestowed much care and the labour of many years, and in which he has collected a vast amount of matter bearing on the private life and habits of a too little known astronomer and mechanician, whose assistance contributed greatly to the success of Flamsteed's work at the Greenwich Observatory.

Abraham Sharp was born in 1653. He was the youngest but one of the ten children of John Sharp, the Parliamentarian, who fought under General Fairfax during the civil war and acted as his secretary during the western campaign. Abraham Sharp was born at a time when Oliver Cromwell was practically king of England. The town of Bradford, near to which the Sharp family had lived for generations, had sustained two sieges, and its defenders had been worsted by the Royalist forces. The town was then one of the chief centres for the manufacture of woollen cloth, and Abraham's father, John Sharp, combined the occupation of a cloth manufacturer with that of farming his own land, which lay around Little Horton. Neither of these occupations was congenial to Abraham Sharp, and on leaving Bradford Grammar School at the age of sixteen, his father apprenticed him to William Shaw, a mercer of the city of York. Mr. Cudworth gives the indenture of apprenticeship which has been preserved, from which it appears that William Shaw was to "teach his apprentice the trade or misterie of a mercer and in due manner to chastise him."

The embryo astronomer did not take kindly to his new surroundings, and long before his term of apprenticeship was out he left his York master, who was probably glad to be rid of such an uncongenial assistant, and started a school at Liverpool, where he taught writing and accounts, and tried to instruct himself in navigation and mathematics. Tradition states, that while in Liverpool he became acquainted with a merchant, in whose house in London Flamsteed was boarding. From the merchant he heard of Flamsteed's learning, and in order to be brought in contact with so gifted an astronomer, Sharp engaged himself as book-keeper to the merchant, and came to London. From Sharp's memorandum books, and Flamsteed's letters, Mr. Cudworth shows that Sharp lived with Flamsteed in 1684 and 1685, and that he became his assistant at Greenwich in 1688. In the third volume of the *Historia Cœlestis*, in speaking of the mural arc, Flamsteed says :—

In May, 1688, J. Stafford, my amanuensis, died, and in the following August I employed in his place Abraham Sharp, a man much experienced in mechanics, and equally skilled in mathematics. He strengthened the rim with screws, carved the degrees upon it, affixed an index, and made all and each of its parts so skilfully that it was a source of admiration to every experienced workman who beheld it.

Nearly all the observations of the *Historia Cœlestis* were made with this mural arc, and from the date of its use the real work of Greenwich Observatory may be said to commence. The accuracy of its divisions, laboriously made by Abraham Sharp, and the general superiority of its workmanship enabled the first material advance on the work of Tycho Brahe to be made in determining the places of the stars and moon.

Turning to Abraham Sharp's memorandum books, which were kept with businesslike accuracy in a very neat hand, we find several interesting details with respect to this famous instrument. Under the date August 18, 1688, are the items :—

Pd ye men tht brt up the instrument	£0	0	4
Pd Roger Bates for the platform and or. things for the quadrant	0	11	6
Spent on ye men that carried the quadrant up to Greenwich	0	0	6
Pd for bringing ye deals from ye yard	0	0	4
Laid out for Mr. Flamsteed for lignum vitæ	0	6	0

From the entries in these books Mr. Cudworth finds that Sharp was in the employment of Flamsteed at a very small stipend, which was not sufficient to maintain him. There are occasional entries of 15*l.* received from Mr. Flamsteed, with several entries of money received from "my brother and cozen." The inadequacy of his salary may no doubt be explained by the fact that Flamsteed's own stipend as Astronomer Royal was only 100*l.* a year, and for this he

was expected to undertake the instruction of two boys from Christ's Hospital in addition to his astronomical observations.

After seven years' work as assistant at Greenwich Sharp left. The reason of his going does not appear. Mr. Cudworth suggests that it was on account of his health. Flamsteed continued to correspond with his old assistant and friend during the rest of his life. Mr. Cudworth gives a long series of Flamsteed's letters with Sharp's answers; but we must confess to some disappointment at not finding more new matter. Baily and De Morgan seem already to have extracted the cream from the correspondence. On many of the letters received by Sharp and in his note-books are copious notes in shorthand, presumably the drafts of his answers. Mr. Cudworth says:—

> The system in vogue in Sharp's time (and which was then commonly acquired in order, it is said, the more readily to record the long-winded sermons of the period) is now obsolete . . . The characters are beautifully formed, as might be expected from the nicety of his caligraphy. In justice to Professor Baily's efforts, it is proper to state that we have been equally unsuccessful in deciphering Mr. Sharp's shorthand notes, and in consequence the purport of much that he wrote to his numerous correspondents is enshrouded in obscurity.

What would that successful stockbroker and admirable astronomer, Mr. Baily, have said if he had heard himself called "Professor Baily"? We believe that he was not quite unsuccessful; at all events, his friend, Mr. Babbage, claimed to have made out the shorthand alphabet which Sharp used, and to have deciphered at least one of the letters. Some effort ought to be made to induce experts to decipher these notes. For Sharp was in correspondence with Halley as well as Flamsteed, and, if Mr. Cudworth is right, with Newton also.

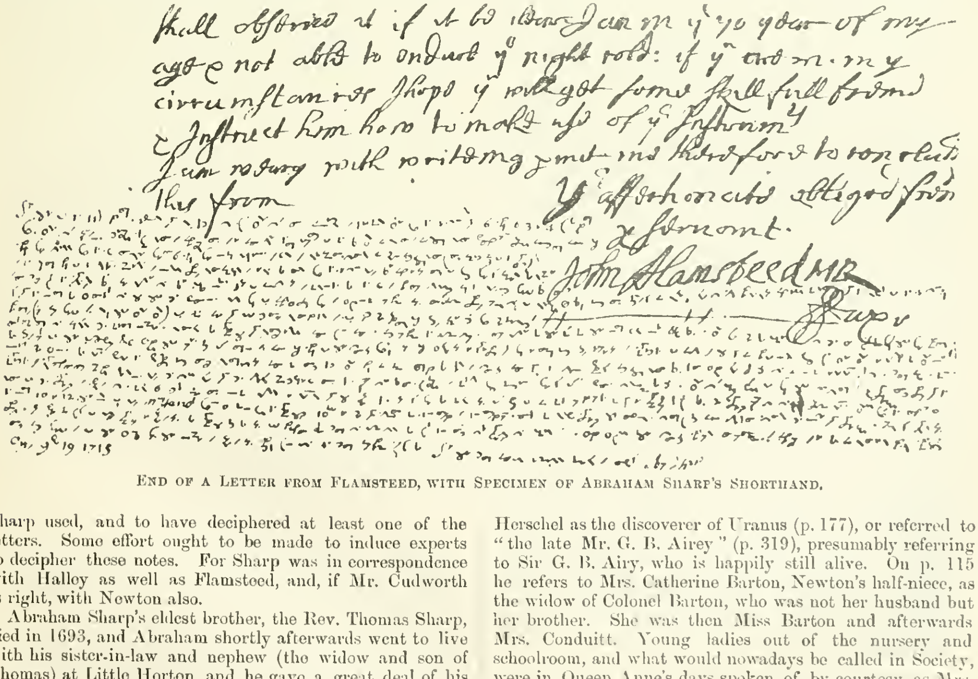
Abraham Sharp's eldest brother, the Rev. Thomas Sharp, died in 1693, and Abraham shortly afterwards went to live with his sister-in-law and nephew (the widow and son of Thomas) at Little Horton, and he gave a great deal of his time to managing the family property till the death of his nephew in 1704. He was then fifty-one years of age, and wrote to Flamsteed:—

> My delay in returning answer to your two so exceedingly obliging letters had been absolutely unpardonable had not a merciful Providence pleaded my excuse, which has so troubled and perplexed me that it is with much trouble and discomposure I now write. It has pleased God to take out of this world my nearest kinsman and only nephew, a young man ever hopeful, in the flower of his age, who had a few years ago been a student of physic at Leyden. A good proficient for his time, just beginning to practise, of good parts and solid judgments. The only son of a most disconsolate mother, him on whom the hopes of a family depended which has continued here in the same name over 500 years—now likely to be extinct. The only person here with whom I could have any agreeable converse.

Abraham Sharp remained a bachelor and continued to live at Little Horton till his death at the age of ninety, in 1743. He occupied himself till the last in grinding lenses and in mathematical pursuits. His "Geometry Improved" appeared under the signature, A. S. Philomath, in 1717. Sharp calculated the "Quadrature of the Circle" to 75 places of decimals and proved the accuracy of his determination of π by a second method to 72 places. Halley, in an essay on the Quadrature of the Circle communicated to the Royal Society, wrote:—

> The problem had tempted the ready pen of the most imcomparable Mr. Sharp, who had contrived to double the famous numbers of Van Ceulen,* a degree of exactness far surpassing all belief.

The minute details given with respect to Abraham Sharp's private life are most interesting from an antiquarian point of view. It would have been well if Mr. Cudworth had induced some astronomical friend to look over his proof sheets. He would then not have spoken of Sir John Herschel as the discoverer of Uranus (p. 177), or referred to "the late Mr. G. B. Airey" (p. 319), presumably referring to Sir G. B. Airy, who is happily still alive. On p. 115 he refers to Mrs. Catherine Barton, Newton's half-niece, as the widow of Colonel Barton, who was not her husband but her brother. She was then Miss Barton and afterwards Mrs. Conduitt. Young ladies out of the nursery and schoolroom, and what would nowadays be called in Society, were in Queen Anne's days spoken of, by courtesy, as Mrs. or Mistress. On p. 76 Mr. Cudworth speaks of the "Principia" being published "through the persistence of Dr.


shall observe it if it be done I am in ye 70 year of my age & not able to endure ye night cold: if ye can in my circumstances shop ye will get some skillfull friend & instruct him how to make use of ye Instrumt
I am weary with writeing & must therefore conclude this from
Yr affectionate obliged friend & servant
John Flamsteed MR

End of a Letter from Flamsteed, with Specimen of Abraham Sharp's Shorthand.

* A Dutch mathematician, who calculated the value of π to 35 places of decimals.

Halley, the cost being defrayed by the Royal Society." This is a mistake worth correcting, for it cannot be too widely known that Halley is the benefactor of mankind who not only urged Newton to the writing of the "Principia," but saw it through the press and paid for its publication. It was not the funds of the Royal Society which were used, though the words on the title-page, *Jussu Societatis Regiæ*, have misled many others besides Mr. Cudworth. In the case of books printed at the expense of the Royal Society it was then customary to use the words *Jussu et Sumptibus*. But the matter is conclusively proved by an entry in the Royal Society minutes for June 2, 1686, where it was ordered "that E. Halley shall undertake the business of looking after it and printing it at his own charge, which he engaged to do." This fact with respect to the printing of the "Principia" was pointed out some years ago by Professor Grant. A. C. R.

The Construction of the Wonderful Canon of Logarithms. By JOHN NAPIER, Baron of Merchiston. Translated with Notes and a Catalogue of Napier's Works, by W. RAE MACDONALD, F.F.A. (Blackwood & Sons, Edinburgh and London. 1889.)—Mr. W. Rae Macdonald has conferred a favour upon the student of mathematical history by publishing a translation of Napier's "Mirifici Logarithmorum Canonis Constructio," the work in which the original conception and construction of the first table of logarithms are described. The table or "Canon" itself appeared in 1614, accompanied by the "Descriptio," or explanation of its use, a translation of which, by Edward Wright, was published in 1616 (after the translator's death). But Napier's "Constructio," or account of the manner in which the "Canon" was constructed, did not appear until 1619, two years after the author's death, when it was edited by his son Robert Napier. Besides a translation of "Remarks" by Briggs, who, as is well known, devoted himself to the computation of a table of logarithms to the base 10 (the advantage of which was perceived by Napier himself), Mr. Macdonald gives some useful notes, a short biographical introduction, and a list of the various editions of Napier's works, with the names of the principal public libraries in this country, as well as of some on the Continent, which have copies. The "Constructio" is very rare, and the library of the British Museum does not appear to possess a copy. But Mr. Macdonald has overlooked that there is a copy in the library of the Royal Astronomical Society.

Planetary and Stellar Studies. By JOHN ELLARD GORE, F.R.A.S., M.R.I.A. (Roper & Drowley. 1888.)—This is really a charming little book, most beautifully got up, and, as might be expected from an astronomer of Mr. Gore's standing, all the information has been brought forward to date, while many of the papers are new or have been re-written. The illustrations are especially good. There is much information here which could not be obtained elsewhere without ransacking scores of volumes. A sentence about "Neith," on page 31, reads rather like the riddle of the Sphinx; and we think that a reference to the "Histoire Céleste," or the seventh volume of the "Bonner Beobachtungen," might clear up some of the discrepancies in Lalande's magnitudes referred to in the chapter entitled "Some suspected variables of the Algol Type." But these are very minor matters.

Astronomy for Amateurs, edited by JOHN WESTWOOD OLIVER. (Longmans, Green & Co. 1888).—This very interesting little volume consists of a series of papers, contributed by many well-known amateur and professional astronomers, which have been passed through the press by Mr. Oliver. A good deal of the work is not exactly new (the chapter on "Double Stars," or at least the greater portion of it, appeared in the *English Mechanic* some time before it was reprinted in the *Sidereal Messenger*), but the work, as a whole, is well done. We should specially single out for commendation Mr. Elger's article on "The Moon"; Mr. Denning's on "Comet Seeking"; Mr. Barnham's (*facile princeps* he of living double-star discoverers and observers), with Mr. Gore's additions; and Mr. Backhouse's on "The Zodiacal Light." The last five lines of page 128 read rather curiously, and is Mr. Denning certain that "the next good opportunity for studying the ring-system will occur in 1907"? H. SADLER.

A Manual of Cursive Shorthand. By HUGH L. CALLENDAR, B.A., Fellow of Trinity College, Cambridge. (London: C. J. Clay & Sons. 1889.)—As the result of a practical acquaintance with the Pitman method of shorthand, and a series of experiments with an electric chronograph, to determine the relative time occupied in making certain shorthand signs, Mr. Callendar has declared against the geometrical school of shorthand, and has produced a system on the cursive plan, in which he embodies joined vowels and alternative devices for indicating vowel-places, three principles which are rapidly gaining favour in shorthand circles. A system constructed on such a plan is bound to be facile and legible. Mr. Callendar's forms are pretty to the eye, but his devices appear too numerous to enable us to grasp the system rapidly. A student, however, would not perhaps find any difficulty in quickly learning it. To those already practising other systems this little book will be interesting and of much value on account of the scientific and effective manner in which the author has dissected the Pitman geometrical method, and exposed its weak points. His arguments appear unanswerable.

Tables, Memoranda, and Calculated Results for Farmers, Surveyors, Land Agents, &c. (Crosby Lockwood & Son, 1889.)—Those who are interested in the management and cultivation of land will welcome this handy little volume, which is literally small enough for the waistcoat pocket. It contains practical directions for measuring land and timber, for the construction of farm buildings, with concise information as to manures, cropping, feeding, and dairy management, which is given in very clear language, and brings together the results of the most recent experiments, so as to be easily referred to. We are pleased to find a very intelligible system of farm accounts, which will be welcome to many farmers of the new order of things, who have not the same horror of putting pen to paper as some of their predecessors. The tables of weights and measures are very full, and illustrate how terribly complicated and diverse are our ways of doing business. There are no less than nine different acres given. This leads us to remark the omission of the metric system, which must sooner or later come into more extensive use in this country.

Notes.

Science is nothing more nor less than the refinement of common sense, making use of facts already known to acquire new facts.—SIR H. DAVY.

In the Berlin Botanical Gardens the rare plants are photographed at the time of flowering, and prints are sent to the other botanical gardens of the empire.—*Invention.*

The foreign population of Paris is extraordinarily mixed in character. Recently foreigners were required to report themselves between October and January, and it appears (*Revue Scientifique*) that 170,262 persons of both sexes were then registered as living in the department of the Seine.

We give some of the higher figures:—Belgians, 43,712; Germans and Alsace-Lorrainers, 26,109; Swiss, 25,144; Italians, 24,178; Luxemburghers, 14,692; English, 7,688; Dutch, 3,770; Americans, 2,302.

Mr. Lant Carpenter has kindly fulfilled several of Mr. Proctor's lecture engagements, handing over the proceeds to Mr. Proctor's widow and children. At a lecture given at Crewe, Mr. Carpenter showed the action of Mr. Edison's improved phonograph. Its construction was explained by the aid of lantern photographic slides, some of which had been taken by the lecturer and some of which were lent by Colonel Gouraud. Remarkable instances were given of the perfection with which the instrument reproduced not only speech, but music and sounds of all kinds. This perfection is due to minute details of construction. The lecture was concluded with a description of the Berliner gramophone, by which the "speech records" (or phonograms) can be multiplied almost indefinitely by electrotyping, and may then be widely distributed. A pontifical blessing, for example, might be thus reproduced in various parts of the world, for the edification of the faithful, in the original papal tones of voice.

A curious treatment of rheumatism, viz. bee-stings, has been lately practised by Dr. Terc in Vienna, who describes it in a medical paper. In rheumatic patients swelling only appears after a succession of stings; continuing this unpleasant application the swelling dies down, and the patient is then cured of his rheumatism. Dr. Terc has thus treated 173 cases, making 39,000 stings with bees, of which he keeps a large supply in hives. He has special success with acute and chronic cases. Sometimes "hundreds of stings" are given; but it is right to add that the pain is much less with rheumatic than with healthy people.—From the Vienna *Medicinische Presse.*

An interesting study of the phenomena of sleep and dreams has been recently made (we learn from *Science*) by a Professor Heerwagen, of Dorpat, who sent out queries to various observers, viz. 151 students, 113 other males, and 142 females. Here are some of the results: The vividness of dreams increases very markedly with their frequency. Frequent dreams are a concomitant of light sleep, but not universally. Women have a very much lighter sleep than men, and their dreams are proportionally more frequent. With growing age dreams grow less frequent, but sleep becomes lighter. The student age 20 to 25 seems to be the period of maximum dreaming. Women dream most vividly, and students more than other men. The same relation holds as to power of remembering dreams. Women who dream frequently sleep nearly an hour longer than those who seldom dream. Students sleep longer than other men. The time needed to fall asleep is about the same in all three classes: 20·8 for the men, 17·1 for students, and 21·2 for women. Eighty per cent. of students sleep uninterruptedly through the night, 70 per cent. of other men, and only 23 per cent. of women. The power of falling asleep at will is possessed by few, and is greater in youth than in age.

We learn from *Iron* that, despite the great increase which has taken place in the production of coal in late years, the number of deaths from explosions in mines in 1888 was the *lowest* recorded in any one year since 1851, when the number was first officially given. The lowest death-rate previously to 1888 was in 1884, when 65 persons were killed by mining explosions, while the highest during the last thirty-eight years was in 1866, when the lives lost in our mines through the causes named reached 650, of which upwards of 360 resulted from the explosion at the Oaks Colliery, near Barnsley. In 1888, however, the deaths from explosions only numbered some 43. This great decrease is, no doubt, due to the precautions which a scientific study of the subject has suggested.

RARE ELEMENTS IN BEETROOT SUGAR RESIDUES.

Edmund O. von Lippmann has recently made a careful analysis of the liquor obtained in the manufacture of sugar from beetroot, with a view of discovering what rare elements are absorbed by the roots. He finds that the ashes of the beetroot contain considerable quantities of the metal vanadium, and has detected manganese, caesium, and copper in traces, not only in the roots but also in the leaves and in the raw products. Rubidium also is present in the ashes of beetroot.—*Industries.*

THE FACE OF THE SKY FOR MARCH.

By Herbert Sadler, F.R.A.S.

A FEW scattered groups and single sunspots may be perceived from time to time, but the absence of any striking phenomena of this kind is still a marked feature of the solar surface. Conveniently observable minima of Algol occur at 8h. 19m. P.M. on the evening of the 8th; at 10h. 1m. P.M. on the evening of the 28th; and at 6h. 50m. P.M. on the evening of the 30th. The variable star R Leonis (R.A. 9h. 41m. 36s. N. Decl. 11°57′) attains a maximum on the 23rd. This star is of a beautiful red colour, and has been seen as bright as the fifth magnitude at maximum, though it is usually about the sixth. It is situated a little less than half the distance between Regulus and ξ Leonis, very slightly south of the line joining them, and is in the field of view with a white 7th magnitude star, 19 Leonis, about $8\frac{1}{4}'$ south of it, R forming an isosceles triangle with two $8\frac{1}{2}$ magnitude stars close by. Mercury is a morning star throughout the month, but is not well situated for observation, as he rises in bright twilight with considerable south declination. He is at his greatest elongation west ($27\frac{1}{2}$°) on the 13th. Venus is now a resplendent object, visible to the naked eye at noonday, and casting a distinct shadow at night in the absence of the moon. She sets on the 1st nearly four and a half hours after the sun, her diameter being 27″, and her northern declination $13\frac{1}{4}$°. On the 25th she is at her greatest brightness, five times as bright as Jupiter. Venus will be seen at this elongation with unusual brightness owing to the season of the year and her northern declination, and appears as a moon just over five days old, with an apparent diameter of 37″ and a northern declination of $21\frac{1}{2}$°. She is then about forty-one millions of miles distant from us, and sets $4\frac{1}{4}$ hours after the sun. Shortly after 8 P.M. on the 9th she will be in conjunction with a star just visible to the naked eye (No. 1482 of Hora I. of Weisse's Bessel) $6\frac{1}{2}'$ south of the star, and at 6 P.M. on the evening of the 17th she will be about 15′ to the east and very slightly north of the 6th magnitude star 26 Arietis. The student should now take every opportunity of examining the disc for spots and for the remarkable "phosphorescence" of the dark side. Both phenomena have been seen with very small instruments. Mars is, for the observer's purposes, practically invisible; as though he sets 2h. 40m. after the sun on the 1st, his apparent diameter is less than 5″; and Jupiter does not rise till after 2 o'clock on the morning of the 31st. Of the minor planets Juno comes into opposition with the sun on the 20th, at a distance from the earth of 177,000,000 miles, and appears as an $8\frac{1}{2}$ magnitude star, being on the evening of the 13th 1° 51′ due north of η Virginis. The actual diameter of this pocket planet is probably only 110 miles. Pallas

appears as a dull $7\frac{1}{2}$ magnitude star, having an apparent diameter of 165 miles according to the photometric observations of Argelander, Stone, and Pickering (though Lamont, from direct measurement of the apparent diameter of the disc, raised this value to 630 miles), and passes the meridian at 5h. 24m. P.M. on the evening of the 17th. On the evening of the 19th she is 1° 40′ due north of Rigel, and on the evenings of the 28th and 29th, she is extremely close to the 5th magnitude star v (Upsilon) Orionis. Saturn is very favourably situated for observation, rising on the 1st at 2h. 54m. P.M., and just before 1h. P.M. at the end of the month. He describes a short retrograde path through a barren portion of Cancer. On the evenings of the 4th, 5th, and 6th, the satellites Titan and Iapetus will both be near the planet; Titan being to the north, and Iapetus to the south. The latter satellite will not be visible in small telescopes after the middle of the month until April, as he is at his eastern elongation on the 27th, about which time he is almost as faint as the faintest satellites. Uranus describes a very short retrograde path in Virgo, being 2° 55′ due north of Spica on the evening of the 9th. On the 1st he rises at 9h. 16m. P.M., and on the 31st at 7h. 12m. P.M. Neptune is in Taurus, describing a very short arc between the Pleiades and Hyades, but he does not approach any conspicuous star. There are no marked meteor showers in March. The Zodiacal Light may be looked for on moonless nights, after the last traces of twilight have disappeared, in the form of a faint spindle-shaped or lenticular cone of light extending from that part of the heavens where the sun has set to about 46° or 50° in length, and forming an angle of about 60° with the horizon. The brightness of Venus at the present time will, however, probably render the phenomenon difficult of observation for the ordinary observer. The moon is new at 10h. 1m. P.M. on the 1st, enters her first quarter at 5h. 59m. P.M. on the 9th, is full at 11h. 47m. on the morning of the 17th, enters her last quarter at 6h. 54m. A.M. on the 24th, and is new again at 11h. 37m. on the morning of the 31st. On the 9th there will be a near approach of the $6\frac{1}{2}$ magnitude star B.A.C. 1651 at 5h. 34m. P.M., at an angle of 4° from the vertex, and an occultation of B.A.C. 1733, $6\frac{1}{2}$ magnitude, at 36 minutes after midnight, at an angle of 156° from the vertex, the star reappearing at 1h. 28m. on the morning of the 10th, at an angle of 283° from the vertex. At 2h. 30m. on the morning of the 16th the 5th magnitude star l (53) Leonis will disappear at an angle of 40° from the vertex, and will reappear at 3h. 4m., at an angle of 341°. On the 22nd B.A.C. 5408, $6\frac{1}{2}$ magnitude, will disappear at 2h. 32m. A.M., at 50° from the vertex, and reappear at 3h. 45m., at an angle of 248°, while at 3h. 19m. on the morning of the 26th the 6th magnitude star 4 Capricorni will disappear at an angle of 25° (the moon and star not having risen at Greenwich at the time), and will reappear at 4h. 15m. the same morning, at an angle of 272°.

Our Whist Column.

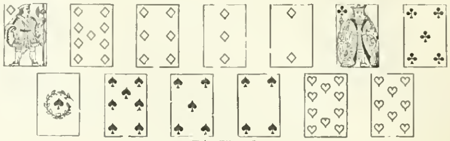
By W. MONTAGU GATTIE.

ANSWERS TO CORRESPONDENTS.

G. WILLINS.—You should have scored 7 points—i.e., 2 for the double, 3 for the treble, and 2 for the rubber.

HAND No. 2.

THE following hand, which is taken from actual play, affords a simple illustration of the importance of retaining a card of partner's suit until the right moment arrives for putting him in. It is frequently, as in the present instance, good policy for an opponent to defeat these tactics, if possible, even at the sacrifice of the best trump.



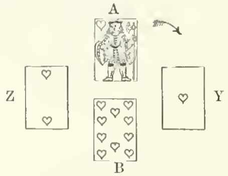
B's Hand.

Score—Love all.

Z turns up the 7 of Diamonds.

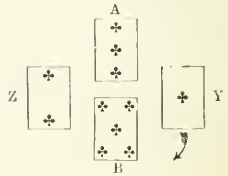
NOTE.—A and B are partners against Y and Z. A has the first lead; Z is the dealer. The card of the leader to each trick is indicated by an arrow.

Trick 1.



Tricks—A B, 0; Y Z, 1.

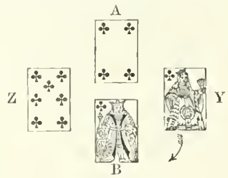
Trick 2.



Tricks—A B, 0; Y Z, 2.

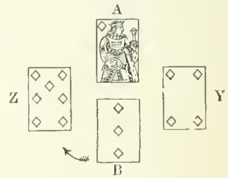
NOTE.—*Trick* 1. A's lead is almost certainly from king, queen. knave, and at least two others, in which case he has already the command of the heart suit. Having five trumps to an honour, and some protection in spades and clubs, B is fairly justified in commencing a call for trumps.

Trick 3.



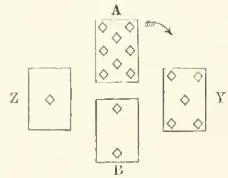
Tricks—A B, 1; Y Z, 2.

Trick 4.



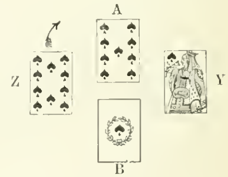
Tricks—A B, 2; Y Z, 2.

Trick 5.



Tricks—A B, 2; Y Z, 3.

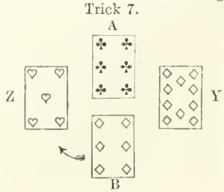
Trick 6.



Tricks—A B, 3; Y Z, 3.

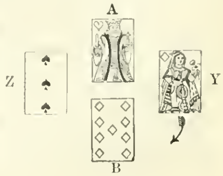
NOTE.—*Trick* 5. After this trick it is clear to B that the remaining trumps (Qn 10) are with Y; for Z's smallest was the 7 (Trick 4), and he has now had to win the 8 with Ace; and A has shown by his play to Trick 4 that he has not the queen, and by his lead at Trick 5 that he has not the 10. *Trick* 6. Z has evidently (to B) led from Kg, Kn, 10, and others; for if either A or Y had held the knave he would have played it; and, since Z must therefore have the knave, he of course has the king also.

Trick 7.



Tricks—A B, 3; Y Z, 4.

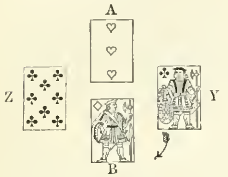
Trick 8.



Tricks—A B, 3; Y Z, 5.

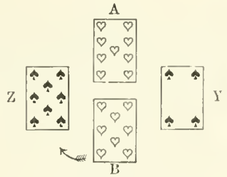
Note.—*Trick* 7. Here lies the point of the hand. Having only one heart, B determines to sacrifice a trick in trumps by leading up to Y's tenace, in the hope that Y will draw another trump with his queen and then continue the clubs. If B returns the heart lead immediately, Y Z make the odd trick.

Trick 9.



Tricks—A B, 4; Y Z, 5.

Trick 10.



Tricks—A B, 5; Y Z, 5.

Tricks 11 to 13. A makes the remaining hearts, and A B Score Two by Cards.

A's Hand.	B's Hand.	Y's Hand.	Z's Hand.
D.—K, 8	D.—Kn,9,6,3,2	D.—Q, 10, 5, 4	D.—A, 7
C.—6, 4, 3	C.—K, 5	C.—A, Q, Kn, 9	C.—10, 8, 7, 2
H.—K, Q, Kn, 9, 7, 6, 3	H.—10, 8	H.—A, 4	H.—5, 2
S.—9	S.—A, 7, 5, 4	S.—Q, 6, 2	S.—K,Kn,10,8,3

Remarks.—Y plays his adversaries' game to perfection. In his anxiety to draw a losing trump, he fails to see the necessity for retaining his queen to block the heart suit. He might have foiled B entirely, and secured the odd trick, by continuing the club suit at Trick 8; for B, after ruffing, would have had no choice but to lead hearts. Y might also have made two by cards by returning the spade suit at Trick 9, but he could not be certain that his partner held the king and knave, which might have been with A and B respectively. Z's lead at Trick 6 may have been forced, for (owing to B's finesse) he could not tell that the knave, 10, of trumps were not with A, and would therefore hesitate to return the club suit, in which either A or B must be void.

Elementary Explanation of the Play.

Trick 1.—A opens his long suit, and leads one of his head sequence in order to draw the ace, and so obtain command of the suit. As he has more than four hearts he leads the knave; with four only he would lead the king. Y, as second player, plays correctly in putting his ace on knave led. B commences to call for trumps by playing the ten of hearts instead of the eight.

Tricks 2 *and* 3.—Y in turn opens his strong suit. This is the orthodox lead from ace, queen, knave; the king comes out in the second round, and Y remains with the command.

Trick 4.—B leads his "penultimate" trump (the lowest but one) to show that he has five. He infers from this trick that the ace of trumps is with Z.

Trick 5.—A of course returns trumps, and B finesses the eight. A little reflection will show that, as the ace is on his left, he can lose nothing by this course; while, on the other hand, he may be a gainer if, as turns out to be the case, the ten is on his right. B infers from this trick, as already explained, that the remaining trumps are in Y's hand.

Trick 6.—Z opens his strong suit, and, holding king, knave, ten, he rightly leads the ten. The suit is cleared in one round, and B is able to infer that Z has the command; but A and Y cannot at present be certain that Z has not led the highest of a three-card suit. From A's point of view, B may hold the knave and Y the king, and Y cannot tell that B has not the knave and A the king.

Trick 7.—B knows that Y has tenace over him in trumps (i.e. best and third best against second and fourth best), and by leading up to this tenace he loses a trick in trumps; but, if he returns the hearts immediately, they will probably be trumped very soon, and he will never be able to put his partner in again. Therefore he runs a small risk in the hope of getting out the adverse trumps before giving his partner the heart.

Trick 8.—Y plays the "book" game in drawing a losing trump. His error in the present instance has already been explained. A discards his best heart to show his partner that he has absolute command of the suit. This is often a very useful hint, and may always be adopted if there is no danger of its being mistaken for a call for trumps.

Knowledge is not like food, destroyed by use, but rather augmented and perfected.—Sir John Herschel.

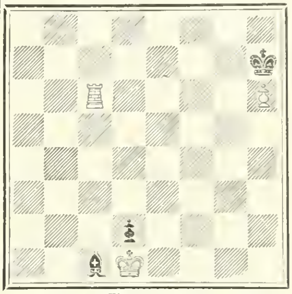
Our Chess Column.

By I. Gunsberg (Mephisto).

[Contributions of general interest to chess players are invited. Mr. Gunsberg will be pleased to give his opinion on any matter submitted for his decision.]

We much regret that the End-game given in our February number was defective, owing to the Rook being misplaced on QR6 instead of QB6. We now give the corrected position, together with the solution.

Black.



White.

White to play and win.

The win is brought about by White so playing his Rook that the black Bishop cannot be brought into play to attack the white Pawn, and the manner in which the white Rook limits the action of the B is instructive; the idea has been embodied in many problems. But, if the black King moves instead of the B, White plays his R on the 7th file, and also plays P to R7, compelling K to Rsq, when Black will be compelled to play his B. Then a rapid advance of the white King, although it does not prevent Black winning the white Pawn, will, however, bring about one of the positions in which the Rook wins against the Bishop. White begins with

1. R to R6

To prevent B to R6, as he threatens then to play B to Bsq; and even if White prevents this, Black has gained sufficient time to draw. B to Kt2 is, however, no good now, as White just gains the one move necessary to win, i.e., 1. R to R6, B to Kt2; 2. K × P, B to K4; 3. K to K3, B to Kt7; 4. R to B6, B to R6; 5. K to B4, B to Bsq; 6. K to Kt5, and should win.

	1. K to Ktsq
2. R to R7	2. K to Rsq

The white King must never move as long as the white Pawn is on R6, for then Black would always Queen his Pawn and get the white Pawn. It would also be wrong to play 3. P to R7 now, for Black would play B to Kt7, followed by B to Kt2, and gain the Pawn. White now plays

3. R to Q7

Because B to R6 and B to Bsq need not be feared now, as White would pin the B on Bsq by R to Q8; nor can Black play his B anywhere else from R6 with advantage, for after K × P White will, as on the preceding move, reach his Pawn in time or give it up, and win, as the following interesting variation will show:—3. R to Q7, B to Kt2; 4. K × P, B to B3; 5. K to Q3, B to Kt4; 6. P to R7, B to R6; 7. K to K4, B to Kt2; 8. K to B5, K × P; 9. K to Kt5, K moves; 10. K to Kt6, and wins. This is the main idea, and its success depends on gaining one move, which enables the King to come up just in time to bring about the winning position. But if instead of this Black plays

	3. K to Ktsq
4. P to R7 (ch)	4. K to Rsq
5. R to Kt7	

To prevent the B playing to Kt7 and Kt2 too early,

	5. B to R6
6. K × P	6. B to Q3

If 6. B to Bsq instead, then 7. R to Kt8 wins; or if 6. B to Q2, then 7. R to Kt8 (ch), K × P. 8. R to Kt7 wins.

7. K to K3	7. B to K4
8. K to K4	8. B to Kt2
9. K to B5	9. K × P

And, again, White has arrived at the same position as given in our note to White's third move, and wins by

10. K to Kt6 followed by 11. R to Kt8.

END-GAME No. 2 (FEBRUARY).

Position White. P on KKt2; K on KKt3; Q on KKt4; Kt on KKt5; B on KKt6.

Black. K on KKtsq.

White to play, and mate in seven moves with the Pawn.

Alex. Main, Middlesbrough, sends the following solution:—

1. Kt to K6, K to Rsq; 2. B to B7, K to R2; 3. Q to Kt8 (ch), K to R3; 4. B to R5, K × B; 5. K to R3, K to R3; 6. Q to Kt7 (ch), K to R4; 7. P to Kt mate.

A. C. W. has found another solution in 1. Q to Q7, K moves: 2. B to B7, K to Kt2; 3. Q to Q8, K to R3; 4. K to R3, K to Kt2; 5. B to R5, K to R3; 6. Q to B6 (ch), K × B; 7. P to Kt4 mate.

THE MAGIC SQUARE KNIGHT'S TOUR.

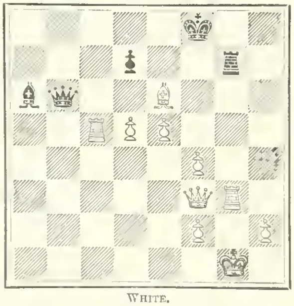
In view of the great interest that is manifested in the subject of magic squares, we present a perfect magic square Knight's tour.

260 =	260 =	260 =	260 =	260 =	260 =	260 =	260 =	= 2080
1	30	47	52	5	28	43	54	= 260
48	51	2	29	44	53	6	27	= 260
31	46	49	4	25	8	55	42	= 260
50	3	32	45	56	41	26	7	= 260
33	62	15	20	9	24	39	58	= 260
16	19	34	61	40	57	10	23	= 260
63	14	17	36	21	12	59	38	= 260
18	35	64	13	60	37	22	11	= 260

This square illustrates the Knight's tour over the chess-board, in which the Knight plays to every square on the board, and touches it but once. Every line of figures running up and down sums up 260. Every line of figures running right and left sums up 260. Divide the board into four quarters; then the rows and files of each quarter will sum up 130. Divide the board into sixteen equal parts; the numbers that compose each sixteenth part will sum up 130. It also follows that any sixteenth portion of the board, added to any other sixteenth portion, will sum up 260. It also follows that any half row or file, added to any other half row or file in the entire square, will sum up 260. Take the files of numbers running up and down; the four central numbers of the file will sum up 130; and so of course the four remaining or outer numbers will sum up 130. These are only some of the wonderful properties of this mysterious square. This is really a *magic square*; and in comparison the ordinary square by this name sinks into insignificance.

The following ending occurred in a game played recently at Simpson's, in which an amateur received the large odds of Knight and move. His play on this occasion, though unsound, seems like the dawn of awakening genius, which will no doubt soon place him in an exalted position, far and above the odds received in the game. But, by showing the danger he ran, we hope to put our readers on their guard against attempting unsound moves, in spite of their occasional success.

MASTER.
BLACK.



WHITE.
AMATEUR.

White played

1. K to Kt2

Played with audacious intent, to deceive an old hand, as will be seen from the sequel. However ingenious, it was not the strongest move, which was 1. Q to R3, which would win easily.

1. Q to Kt8

Black rushes into the trap so skilfully prepared, as the odds giver must in a position like this seize chances, however slight they may be, that the weaker player may not see the dangers of his position. In reality, however, Black had no very good move; for, if 1. Q × R, then White would reply with 2. R × R, which the black King could not retake, as White could force a mate by Q to Kt4 (ch), &c. P × B likewise leaves Black with a hopeless game.

White now plays the trump card of his unsound though ingenious conception, which was

2. Q to K2

We do not know whether this move was accompanied by an appropriate ejaculation and accompanying jerk of the hand, as if desirous of withdrawing the move; any way, it had the desired effect, for Black too rashly, but not too wisely, played 2. B × Q, whereupon White mated in two moves, by R to B8 (ch), K to K2, R × R mate. But if, instead of 2. B × Q at once, Black would have looked ere he leaped, and played 2. R × R (ch) first, to be followed by B × Q, then in all probability White's ingenuity would have resulted in he himself losing the game. We therefore say it was very nice, but don't do it again.

HAMPDEN.—Received with thanks, and utilised above.

"THE OWL."—We hope Tyro will benefit by the lesson.

W. T. LOW.—Your communication is very interesting; we will endeavour to act upon what you say. With reference to adopting two openings principally, one for attack and for defence, it must undoubtedly be admitted that this would lead to artificial protection, as the player would at least be certain of not falling a prey to unknown variations; but from a superior point of view it is very undesirable, as in the long run the practice of playing but two openings would stunt the imagination, prevent the development of self-reliance, and thus, and also in other ways, weaken the play as against the player, who by running all risks of playing an open game, even incurring immediate losses to a considerable extent, would nevertheless thereby develop his powers of resource, his confidence in himself, and the fertility of his imagination. In a word, this is merely a principle applicable to a vast amount of subjects, and much ignored at the present time—to wit, artificial *versus* natural selection.

J. HUNTER, SOUTHPORT.—Try Mortimer's "Pocket Handbook on the Openings," published by Wyman & Sons, a most useful little work, the price of which is but one shilling, which is arranged in the tabular form of the synopsis, and contains the leading variations in each opening, to a sufficient extent to inform, but not sufficient to perplex. It is very neatly got up, and the best thing that has been published lately.

GEO. COLEY.—Solution correct. Your wish shall be complied with in due course.

CONTENTS OF No. 40.

TERMS OF SUBSCRIPTION.

1. Broad Ribbon Lightning.—Taken at Battersea, on August 17th, 1887, by G. J. Ninnes.

2. Curtain-like Lightning.—Taken from Westbourne Grove, London, on August 17th, 1887, by E. S. Shepherd.

3. Meandering Lightning.—Taken at Brixton, on August 17th, 1887, by J. Gray.

4. This Photograph—in addition to three bright flashes—shews a *dark* flash. It was taken from Westbourne Grove, London, on August 17th, 1887, by E. S. Shepherd.

5. Meandering Lightning.—Taken at Putney on August 17th, 1887, by A. W. Bates.

6. Ribbon and Knotted Lightning.—Taken at Clapham on August 17th, 1887, by J. Guardia.

CUNNINGHAM & LAWRENCE.

COLLEGE HILL, E.C.

LIGHTNING PHOTOGRAPHS.

KNOWLEDGE
AN ILLUSTRATED
MAGAZINE OF SCIENCE
SIMPLY WORDED—EXACTLY DESCRIBED

LONDON: JUNE 1, 1889.

CONTENTS.

TIGER-BEETLES.—I.

By E. A. Butler.

A DRY, sandy bank, either entirely bare or only scantily covered with vegetation, so that there shall be, not a continuous carpet of verdure, but simply isolated tufts here and there, with bare patches between—a bright sunny morning in late spring or early summer, when the sun's rays are pouring down full upon that bank—these are the conditions of place and time most favourable for observing tiger-beetles in the full play of their activities. Let the observer take his stand at such a spot at such a time, and he will soon become conscious of the rapid, lightning-like dash of some object past him towards the bank, followed by an almost imperceptible thud, but so quick is the movement and so instantaneous the phenomenon, that he may need it repeated several times before he can be quite sure of its reality, and may even then require further scrutiny before he can discover its cause in the rapid movements of these really brilliant, though not very easily detected insects.

Tiger-beetles are among the most active and rapacious examples of the whole order *Coleoptera*, and at the same time some of the handsomest. They constitute a distinct family called the *Cicindelidæ*, and in systematic arrangements stand first amongst the Geodephaga, or carnivorous ground beetles, which again are placed at the head of the whole order. Thus they occupy in systematic zoology a position amongst beetles analogous to that of eagles amongst birds. The only genus represented in this country is the typical one *Cicindela*, of which, again, we possess only four species. Exotic forms are very numerous, and many of them are exceedingly handsome in coloration as well as elegant in form. In general structure the majority of them are so much alike that a description of the commonest English species will be sufficient to make clear the characteristics of the group as a whole.

Our best-known tiger-beetle is called *Cicindela campestris* (fig. 1), and is an abundant insect in all sandy places. Though so common, it is one of the handsomest beetles we possess; above, it is of a bright green colour, which, about the head and thorax, has a little metallic gloss. The microscope, however, effects a great improvement in its appearance; the surface is seen to exhibit a shagreened texture, and in a good light all the little irregularities glitter and sparkle with gorgeous, gem-like tints. Few sights, indeed, are more dazzling in brilliancy than a low-power microscopic view of the fore parts of one of these insects, strongly illuminated as an opaque object. The elytra, or wing covers, are rather flat on the back, with prominent shoulders, and are marked with ten creamy spots, which, in different specimens, vary a good deal, both as to size and distinctness. The colour of the back, too, is variable; sometimes it is of the most intense green, sometimes almost olive-green, and occasionally black. Underneath the insect is, if possible, handsomer than above; the whole under surface is brilliantly polished and of a deep metallic bluish-green, shot here and there with coppery red.

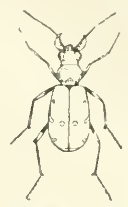


FIG. 1. CICINDELA CAMPESTRIS. The Common Tiger-Beetle.

In the general aspect of these insects there are many indications of the extraordinary rapacity and agility which characterise them. The mouth-organs and legs naturally exhibit the chief peculiarities. The latter are long and slender, reminding one of the similarly modified organs in a gazelle. They are perfect gems of coloration, for which reason they are frequently mounted as opaque microscopic objects, when, for exquisite range of tints, they vie with that favourite object the iridescent hairs of the sea-mouse. Their coloration is hardly seen to advantage till they are removed from the body, when the brilliant ruby red shading into the characteristic green is easily observed. So slender are they, however, and so small, in consequence, is the compass into which their beauty is packed, that it is quite unperceived by the naked eye unless they are examined closely. And this remark applies almost equally to all entomological specimens; the characteristic peculiarities are so minute, even at the best of times, that a person cannot be said really to have seen what an insect is like without making a close and detailed examination, which will often be the means of correcting first impressions, formed after a mere cursory glance. There is no lesson the entomologist needs more carefully to remember than that close and attentive examination is always necessary, even with the most familiar objects, and whoever ignores this is sure to be perpetually making mistakes. The amateur, especially, in meeting with any insect new to him, should never rest satisfied till he has carefully applied at least a hand lens to all parts of its exterior.

If the structure of the legs is indicative of agility, even to a greater extent is that of the mouth organs suggestive of rapacity. The mandibles (fig. 2) or principal jaw must be, at least to the lower creation, truly terrible instruments. Curved, intensely hard, sharp-pointed, and strongly toothed, they give the beetle a most cruel and ferocious aspect, as they project considerably in front of the head, and they are so large that when closed they cross one another like the

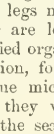


FIG. 2.—MANDIBLE OF TIGER-BEETLE.

opened blades of a pair of scissors. In speaking of an insect's mouth organs, just as of those of a spider, a crab, or a lobster, or any animal allied to these, it is necessary constantly to bear in mind that the jaws are totally different from the parts similarly named in a vertebrate. They are, in fact, external appendages, constituted on the same type as the limbs, though usually very greatly modified in form, and differing in the degree of development of the several parts; their movement also is lateral or transverse—*i.e*, from the sides towards the middle. never longitudinal, as in a vertebrate. If this be borne in mind, it will be obvious that weapons such as the mandibles of a tiger-beetle are eminently adapted for the *capture* of living prey, but that without some other organs to come to their assistance they would be of small use either for tearing it to pieces or for conveying the fragments to the mouth. No object secured between their tips could be brought near the mouth. for, as they are hinged at the base, and their tips describe the arc of a circle, it would obviously be necessary, in order that this should be practicable, that the length of each mandible should not be greater than half the distance their bases are apart. But this maximum is greatly exceeded in the present instance, so that when closed they cross at about the middle of their length. The difficulty is obviated by means of another pair of so-called jaws, the maxillæ, more complex in structure than the mandibles, but at the same time far weaker; to these, which are placed immediately beneath the mandibles, and are furnished with a pair of jointed appendages, the maxillary palpi, is assigned, in concert with a central hinged plate bounding the mouth opening above, and a similarly placed piece bounding it below, the duty of manipulating the food, assisting to pinch off portions of it after it has been already mangled by the mandibles, and guiding them into the aperture of the mouth. The plate which guards the mouth above is called the labrum (fig. 3), and in these insects is enormously developed, forming a kind of lid lapping over the base of the mandibles to a considerable extent, and as it is of a yellowish white colour, and thus contrasts strongly with the prevailing green of the rest of the body, it forms one of the most striking and conspicuous features of the insect. The piece which bounds the aperture of the mouth below is called the labium, and, like the maxillæ, is furnished with a pair of long palpi fringed with hairs. The combined action of all these organs, which, so to speak, play into one another's hands like the parts of a complicated machine, render it almost impossible that any portions of food should fail to reach their destination.

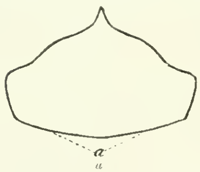


FIG. 3.—LABRUM OF TIGER-BEETLE. *a*. Line of junction with head.

In picturing to ourselves, then, the taking of a meal by this tiger of the insect world, we are not to think of a series of operations like those of its namesake in the vertebrate sub-kingdom, we are not to think of the prey as held down by the fore feet of its captor, while a pair of internal and vertically moving jaws, carrying teeth imbedded in sockets, are tearing it to pieces, the head meanwhile being moved about with the utmost freedom from one side to the other, as the position of the morsel may demand; but we are to imagine the prey secured between two sickle-shaped, external and laterally moving jaws, hinged to a head which, in consequence of the hard and inflexible armature with which it is covered, has but little freedom of movement, and carrying on their inner edges teeth which are not imbedded in sockets, but are simple projections of the substance of the jaws themselves, and while thus held and pinched, we are to imagine it further as played upon by another pair of laterally moving external appendages beneath the jaws, assisted by a central movable plate both above and below, as well as by two pairs of jointed, finger-like palpi, the food being, by the combined exertions of all these organs, gradually reduced to sufficiently small fragments, and passed into the aperture which constitutes the real mouth.

Cicindela campestris is a plucky insect, and if captured, will make sturdy efforts to inflict a wound on its captor by aid of its mandibles; but though these are terrible enough weapons to any unlucky insect that may fall in their way, they are not powerful enough to do harm to human kind, and can only inflict a sharp pinch. In one sense a tiger-beetle is a pleasant thing to hold in the hand, for it emits a powerful and very agreeable scent, which has been variously described as like that of roses, sweetbriar, or crushed verbena leaves; no such description, however, can give an entirely adequate notion of it, and as with most other scents, the only way to understand what it really is like, is actually to smell it. It is rather curious that a carnivorous animal should be pleasantly fragrant; one usually associates odours the reverse of delightful with flesh-eating habits, and most of the other groups of carnivorous beetles fully bear out such a generalisation. A somewhat parallel case, however, is to be found amongst the mammalia, in the civets and genets, which are carnivorous, and are noted for the strong perfume that accompanies them, a perfume so strong indeed as to become almost repulsive, and it may seem not far short of an insult to the tiger-beetle to suggest a comparison. It is another curious coincidence that, as with the tigers and leopards and the rest of the *Felidæ* amongst mammals, we have in these insects an exceedingly handsome coloration associated with the highest development of carnivorous propensities.

(*To be continued.*)

THE NATION'S PURSE.

By ALEX. B. MACDOWALL, M.A.

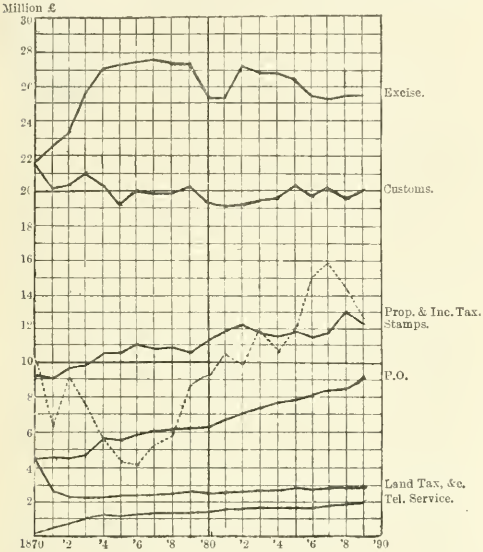
THE graphic method does not seem to have been much applied as yet to the financial statements of the nation. But it is capable of affording a useful *coup d'œil* of the condition of finances in a series of years. We propose to illustrate this month the national revenue and expenditure.

If the average British citizen and voter were required to state off hand how we got our money and how we spent it, in what proportions this or that source contributed to the whole national income, how much we spent on the debt, how much on the army and navy, and so on, and how our income and outlay have varied in the last twenty or thirty years, his answers would, in many cases, we fear, "leave something to be desired" in the matter of precision.

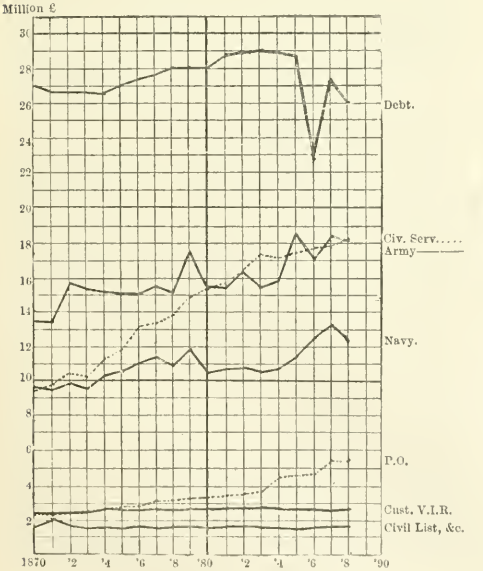
Our two diagrams, attentively considered and fixed in the mind, might possibly help him. The course of a curve, and its relative position among other curves, may be remembered, where long reading or recital of figures leaves comparatively no impression.

These curve pictures show the chief items of revenue and expenditure each year since 1870. The total revenue has risen from 75 to 88 millions; the total expenditure from 68 to 87 millions (roughly speaking). As to the revenue, we may point out that excise is the greatest source,

and note how rapidly the curve rises in the four or five years at the beginning of the period, when there was a striking revival of trade. The great bulk of what the



1. CHIEF ITEMS OF REVENUE.



2. CHIEF ITEMS OF EXPENDITURE.

excise yields each year is, of course, from spirits and beer. Then there are the various licences not only of publicans, &c., but for carriages, dogs, game, male servants, and so on. Of the customs, tobacco yields about one-half; spirits and wine come next, giving about a fourth; then come tea, coffee, various fruits, &c.

Note the wide variations of the property and income tax (dotted curve) and the rise from 1876; also the steady rise of income from the post-office and telegraph service, from stamps, and from land tax and house duty.

Looking now at the second diagram (expenditure), we have first the huge charge of the National Debt, consisting of interest on the "funded" and "unfunded" debt and "terminable annuities." The army and navy curves rise to 18·1 and 12·3 millions respectively. These curves do not show the cost of special military preparations, of which the most notable is represented by the 9 millions voted in 1886; then there was the Egyptian expedition, 3·8 millions, in 1883, the war in South Africa, 3·2 millions, in 1880, &c. The miscellaneous Civil Service curve rises rapidly, the annual amount being about doubled since 1870. The principal objects are here "Law and Justice," and "Education, Science, and Art." The lowest curve relates to charges on the consolidated fund, viz., the civil list, annuities and pensions, salaries, allowances, courts of justice, &c.

This *multum in parvo* graphic method of representation might with advantage, we think, be applied to a variety of the undertakings which involve finance. Thus, it might be interesting to see how the late Metropolitan Board of Works received and spent; and many a harassed ratepayer might welcome a brief and clear vision of how the moneys of school boards, local boards, poor law guardians, and other public bodies, come and go. Once more, one would like to have the finances of certain modern charities thus set forth—enabling one especially to see how much money which should have gone to persons needing to be helped is wasted in quite unnecessary expenses of management.

AN INVERTEBRATE EYE IN THE VERTEBRATE SKULL.

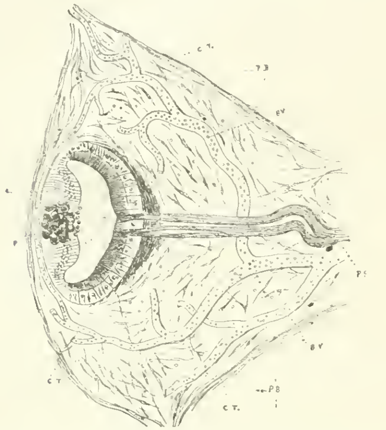
By W. MAWER, F.G.S., Editor of *Life Lore.*

HOW wonderful everything is! the student of nature ever and anon exclaims with a feeling akin to worship. But if men spoke admiringly and awe-fully of the wonders of "creation" in pre-Darwinian times, when all was comparative chaos, with what feelings should they view nature now that the light of evolution streams down upon the universe? There is little doubt that many have been allured to the study of living things since the theory of evolution reduced chaos to order, and that the number of devout inquirers into the mysteries of nature has been enormously increased. Stolid scientists may deem it right to import no feeling into their studies, but the world at large will not avoid varying degrees of emotion—whether standing in front of the ocean, or observing the adaptation of a small organism to its environment. Our present task, however, is not to preach a sermon, but to attempt a description of one amongst a multitude of wonderful phenomena in living things.

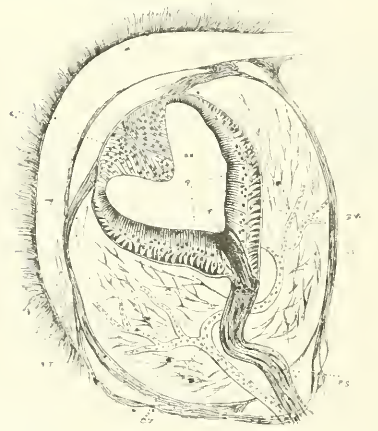
If the skull of a young child were examined, it would be seen that upon its summit is a little place, about as large as a threepenny piece, where the bone has not formed, and where only a thin cartilaginous membrane covers what would otherwise be an opening into the skull. This is the place where the pulsation of blood vessels can be seen in the heads of young babies. It is one of the fontanelles—openings in the brain-case—which are not closed up by the

growth of bone until several months after birth. The term "fontanelle" was no doubt applied to these localities on account of a fancied resemblance of the pulsations there seen to a fountain (*fons*). The particular fontanelle to which attention is now drawn is called by anatomists the *parietal foramen*, because it is a hole through the walls of the skull.

Now that foramen has a very remarkable story to tell of the ancestry of the race of animals in whose skulls it is



SECTION (MAGNIFIED) THROUGH PINEAL EYE OF "VARANUS GIGANTEUS." O V, optic vesicle; P S, pineal stalk (optic nerve); L, lens; P, pigment; R, rods of retina; R', specialised rods at entrance of nerve fibres; C T, connective tissue; B V, blood vessels; P B, parietal bone.



SECTION (MAGNIFIED) THROUGH PINEAL EYE OF "HATTERIA PUNCTATA." References as in section of Pineal Eye of Varanus.

found. It marks, in fact, the position occupied in former generations by an eye. It is in the middle line of the skull, and hence reminds us of the Cyclops.

In some of the lower vertebrates the foramen remains unclosed throughout life, and in some a peculiar structure lies beneath it, of which the function has remained until very recently a complete mystery. It was spoken of by Descartes, if not by more ancient writers, as "the seat of the soul." On account of its shape—somewhat conical, and resembling the form of a pine-cone—it is called the "pineal body." In the human brain it is only seen after separation of the hemispheres, and it lies just in front of the *corpora quadrigemina*. It is larger in children than in adults, and in females than in males. In some amphibians and reptilians the structure is less simple. Lying between the wall of the skull and the connective tissue beneath, it is very liable to be overlooked.

That the pineal body is connected with an atrophied median eye will hardly be doubted after an examination of the structure and its connections in two genera of reptiles —*Varanus* and *Hatteria*—both very old types. The gigantic lizard, Varanus, may be looked at in the Zoological Gardens, Regent's Park. In the median line of the skull is one dermal scale of lighter colour than the surrounding ones. That scale marks the position of the obscured eye. Beneath there lies a perfect structure, a magnified section of which we show in an illustration. There is a crystalline lens, an optic vesicle, a beautiful retina (with its "rods and cones" turned in an opposite direction to that in which they occur in the paired vertebrate eyes—viz., in the same direction as they occur in the eyes of invertebrates), and an optic nerve connecting the structure with the brain. And may not the modified dermal scale represent an atrophied cornea? In Hatteria the eye is just as perfect, nay more so, since the pigment spots are absent from the crystalline lens.

In the little legless lizard known as the "slow-worm" or "blind-worm," the atrophied eye may be found, but no longer united by a nerve-strand with the brain. In the embryo frog it exists in complete connection with the brain; but in the adult the skull has severed the connection, and the eye lies *outside*. In man the eye has entirely disappeared, and what is probably the base of the nerve-strand, the "pineal body," alone remains

In the long-extinct Labyrinthodonts, as well as in some of the Saurians, the parietal foramen presents ridges and grooves which probably indicate muscular attachments concerned in the movement of the eyeball.

Thus the old ancestral invertebrate eye must have survived long after certain offshoots of the invertebrate stock had taken up a distinctly vertebrate structure, and must have been used side by side with, or rather *between*, the paired vertebrate eyes. The ancient beasts, thus doubly provisioned, must have found the paired eyes more useful than the unpaired median eye. It would be impossible to say what different effects upon the brain and consciousness are produced by the turning back of the retinal rods and cones, since we have not the opportunity of comparison, being possessed of only one of the types of eye. But that ancestral forms suffered the one to become functionless by want of use proves the other to have been the better adapted to their requirements. No vertebrate now uses its ancestral invertebrate eye. Where the latter is possessed, it is hidden away beneath opaque tissues, a useless heirloom, but of intensest interest to those higher animals who feel a certain antiquarian affection for what is so pregnant with biological lore. Genealogies which carry us back only some twenty or thirty human generations have entrancing interest for many minds: how does the lesson of the pineal body and the parietal foramen in man compare with these, throwing back his ancestry through long geological ages?

The Queen has been pleased to confer the dignity of a Baronetcy on Professor G. G. Stokes.

CANDLES.

BY W. MATTIEU WILLIAMS.

IN the "good old times," as some folks call them, candles were made at home. In these good times those parts of England that were not barren sandy heaths were well supplied with swamps, in which rushes grew abundantly and without artificial cultivation. These rushes were gathered, soaked, and peeled by children and old women, as Gilbert White tells us. He also adds that "the careful wife of an industrious Hampshire labourer obtains all her fat for nothing, for she saves the skimmings of the bacon-pot for this use, and if the grease abounds with salt, she causes the salt to precipitate to the bottom by setting the scummings in a warm oven." He, however, omits to mention the water in which this melted fat was made to float, and which took away the precipitated salt by dissolving it.

The rushes used for candle-making have an axis of pith, which after peeling forms a very porous thin stick or rod, just stiff enough to be dipped in the bath of melted fat without yielding. The first dip fills the pores, and on cooling the rod becomes much stiffer. Then it is dipped again and again; at each dipping a fresh film of fat is picked up until the required thickness is obtained, and thus the primitive rushlight was made. Whether such candles are still extant I cannot tell, but I well remember them in common use as night-lights when I had the measles. They were sold in London for this purpose, as they required no snuffing.

The next stage was the substitution of cotton for the rush to form the wick. This was accompanied by the industry of collecting "kitchen stuff," and mixing it with slaughter-house refuse, which were melted down to form the home supply of tallow. With the growth of bad habits in respect to late hours, further supplies were demanded and obtained from other countries—such, for example, as the famous brand of P.Y.C. (Petersburg yellow candle) from Russia.

These innovations gradually superseded the domestic manufacture and introduced an intermediate stage, viz., the manufacture of candles by the retailers thereof. One of these establishments in the neighbourhood of Leicester Square happened to fall under my own observation when a schoolboy, and I will therefore describe the public exhibition which afforded much gratification and instruction to self and schoolfellows. The manufacture both of "dips" and "moulds" was conducted in the basement, or kitchen story of the tallow-chandler's shop, and all the mysteries were visible through a grating opening into the street.

The first stage of the dips was the preparation of the wicks to make them hang perpendicularly. This was done by simply dipping the end of each into the melted tallow, and thus forming a knob of tallow, which acted on the cotton like the bob of a plummet. Some dozens of wicks thus prepared were suspended in rows on an oblong frame. A vat just large enough to receive all these wicks was filled with melted tallow. Into this the suspended wicks were dipped three times, and thus received their first coating. This frame was then suspended in its place near the ceiling, and another similarly prepared brought down and dipped, then another, and so on, until the first was cool enough for a second coating. This was repeated until the requisite thickness was obtained. The sufficiency was tested by weighing the frame and its contents. Careful adjustment of the temperature of the melted tallow is necessary: if too hot it would melt away some of that already deposited around the wicks; if not hot enough it would deposit a coating with lumps or blobs. Winter was the busy dipping season.

The mould candles were made by pouring the melted tallow into a shallow trough, into the bottom of which were fitted a number of pewter tubes with conical terminations, and well polished inside. Down the axis of each of these tubes a wick was stretched, terminating in a knot that was drawn up to the small hole at the conical end, through which hole the wick had been threaded. The melted tallow, of course, flowed down these tubes, and thus the candle was cast or moulded.

The dips were for common use, the mould candles for drawing-rooms, for Sundays and evening parties. In those days ordinary people dined at dinner-time, and did not call it luncheon. Very superfine people used wax candles at 3*s*. 6*d*. per lb., or spermaceti candles at even higher prices, and dined at tea-time (5 P.M., and even later). Dining at supper-time was not yet invented, but the cost of winter banquets and evening parties was greatly exaggerated by the expense of lighting the *salons* of the luxurious, and candles were charged among the items of hotel bills—a practice that continued until recently on the Continent.

The snuffing of the tallow candles was a troublesome business; snuffers and snuffer-trays, now preserved in antiquarian museums, were ordinary and necessary articles of domestic furniture. The wax and spermaceti candles consumed their own wicks, but those of the tallow candles formed ugly carbonaceous lumps in the midst of the hollow flame, rendering it smoky and hideous, as well as dangerous, owing to the liability of the red-hot carbonaceous excrescence to fall.

One of the first applications of scientific principles to candle-making was the "patent metallic snuffless wick." The cotton of this was plaited, and through it ran fine wires of fusible metal. The plaiting was so devised that on liberation of its end by the melting of the tallow the wick split out into a sort of angular fork, each branch of which carried its own metal filament. As the ends of these melted, they weighed down their respective branches in such wise that they each leaned over nearly horizontally, and thus projected to the outside of the flame before reaching its middle height.

As the flame of a candle is but a hollow shell, the interior being filled with unburnt gas, and the inside even of the shell of flame itself being ill-supplied with oxygen, the cotton within cannot burn; but on coming through this shell of flame to the outer air it burns readily, being there highly heated and well supplied with oxygen. Thus the cotton of the two outspreading and somewhat pendent forks of the patent wick was reduced to impalpable ash, and its metallic portion to a fine powder of oxide, which fell away as practically invisible dust. Further improvements in the twisting or plaiting of the wicks causing them to droop over in untwisting rendered the metallic filament unnecessary.

The next and most important step was founded on the researches of Chevreul, to which I alluded when on the subject of soap in the January number of KNOWLEDGE. As may be remembered, tallow is composed of fatty acids united with glycerine. This being known, a natural question arises, Are they both of equal value as illuminating agents, or, if not, which is the best? By simply casting a little of each into a fire and observing the result, this question is answered: the fatty acid burns brilliantly, while the glycerine burns with difficulty, giving a dull lurid flame; it is, in fact, but barely combustible at all. Their respective compositions explain this difference.

The fatty acids, broadly speaking, are hydrocarbons, the glycerine a carbohydrate—*i.e.*, the first is composed of hydrogen and carbon, the second of water and carbon, or the elements of water and carbon. In the first, the hydrogen

is ready and eager to burn by combining with oxygen; in the second, the thirst of the hydrogen for oxygen is already satisfied; it can take up no more, and is quite incombustible, as we know to be its condition in water.

Various methods of separating the glycerine have been devised. The first practically carried out was the lime process. About 10 cwt. of tallow or palm-oil was melted with about 140 gallons of water, and to these were gradually added about 100 gallons of milk of lime containing a quantity of lime equal to about 14 per cent. of the weight of the tallow. This mixture was heated and stirred until an insoluble soap was formed by the union of the fatty acids with the lime; the lime, being a stronger base than the glycerine, took the acid away and liberated it, the glycerine thus separated remaining dissolved in the yellowish liquor standing above the soap, from which it was finally separated and purified.

The lime-soap formed by the combination of the lime with the fatty acids is useless, but the fatty acids, having but feeble chemical energy, are easily displaced by a stronger mineral acid which combines with the lime and sets them free. If sulphuric acid is used, solid gypsum is formed, which settles down from the melted fatty acids, which are run off and washed to remove remaining traces of sulphuric acid and gypsum.

When cooled, these fatty acids solidify into a solid of crystalline structure commonly known as stearine, thus named from one of its constituents, the stearic acid. Stearine candles were made from this after pressing out the liquid oleic acid which was used for soap-making.

Other methods followed and superseded this, such as the use of superheated steam to diminish the quantity of lime required, the use of concentrated sulphuric acid, and, better still, the skilful application of the repulsive power of heat, which, at a temperature of about 570° (or a little higher when superheated steam is used as the heating medium), effects the direct dissociation of the fatty acids from the glycerine, and thus separates them in nearly pure condition.

Candles made of the stearine thus obtained are hard and free from greasiness. They burn with a much whiter, purer, and hotter flame than those made of tallow, one of the incidental advantages of this being the full combustion of the wick, as in wax and spermaceti candles (which are composed chiefly of the fatty acids), and therefore no snuffing is required.

Another and still more recent step in candle-making is that of using paraffin, which is a natural hydrocarbon obtained from the tarry oil that comes over when cannel coal and certain bituminous shales are slowly distilled, or, better still, from petroleum. This crude material is washed with sulphuric acid, which carbonises any carbohydrates that may be present by combining with their constituent water, the carbon thus separated sinking to the bottom as "acid tar," and is left behind when the mixture is redistilled.

A curious change is observable in the distillate thus obtained. It is not only refined as regards colour (crude petroleum is brown, and crude shale oil nearly black), but is seen to contain pearly crystalline scales when cold, scales that disappear when the temperature is raised. By lowering the temperature considerably these scales are easily separated by simply straining through suitable bags and pressing the contents of the bags until the liquid oil is so far run out as to leave a hard solid cake of the crystals behind. These, when further refined by washing in light mineral oil, constitute the beautiful substance that has received the name of "paraffin" on account of its lack of chemical affinity. It closely resembles spermaceti, and, mixed with a little wax, is nearly equal to it as a material for candles. Not long ago it was a chemical curiosity, now it is familiar to everybody in the form of the beautiful candles that are retailed at fivepence per pound, less than the former cost of the commonest tallow dips. These require no snuffing, but are inconvenient in hot climates on account of the low melting point of their material.

This defect was ominously displayed at a grand coronation ball given in Mexico by the ill-fated Maximilian. The *salon* was lighted brilliantly with some hundreds of these candles —then a novelty and imperfectly understood. As the dancing proceeded and the room grew warmer and warmer, the candles softened and bowed over, and streams of their melted material poured down so disastrously upon the dresses of the dancers that the ball was hastily terminated.

In all respects but this tendency to "gutter," owing to ready fusibility and the fluidity of the melted material, these cheap candles are equal to the costly wax and spermaceti of the luxurious. Science here, as in other directions, is foreshadowing the future course of human progress, whereby, without any reduction of rational and beneficial refinements and luxuries of the rich minority, the millions gradually and peacefully approach nearer and nearer to a general equality of partaking.

THE OCCURRENCE OF GOLD.

By D. A. Louis, F.I.C., F.C.S.

IN considering the occurrence of gold, there are two or three of its properties which it is useful to bear in mind in order to account for the unique position it holds in the mineral kingdom; these are:—its high specific gravity, the great disinclination it exhibits to enter into combination with other elements, and the peculiarity of its solubility.

Most metals occur in nature mineralised or combined with various elements; for instance, silver is found sometimes free, but most frequently combined with sulphur as in silver glance, also with arsenic or antimony and sulphur in pyrargyrite and proustite, with chlorine in horn silver, and with other elements. Lead is universally found combined with sulphur and galena, also with carbonic acid as cerussite or lead spar, and in other combinations; tin, in its best known ore, cassiterite, is combined with oxygen, whilst zinc in blende is combined with sulphur, and in calamine with carbonic acid. But gold is one of the few elements which exist in nature free or uncombined, and with the exception of its existence in comparatively small quantities, combined with the rare element tellurium, it is always found in the metallic state. Native gold, however, contains varying proportions of impurities, the impurity in most instances being metallic silver, and perhaps copper; therefore we can dismiss the question of the chemical occurrence of gold with the statement that it generally occurs in the free state alloyed with more or less silver, and is sometimes found as telluride.

Turning to its mineralogical or petrological associations, a very similar degree of simplicity awaits us, for gold is, with few exceptions, found associated with the well-known nonmetallic mineral quartz, whilst iron pyrites is the most general metalliferous mineral which accompanies gold, although copper pyrites, galena, blende, and arsenical pyrites are frequently auriferous, and some dozen other minerals are from time to time found to have particles of gold mixed with them. The rocks in which gold is found are mostly metamorphic, or those rocks which have in periods gone by been deposited during the decay of pre-existing rocks, but

have, some considerable time after deposition, undergone changes and, in many cases, have been subjected to great heat, to violent upheavals, disruptions, and compressions, with the result that they have become more or less crystalline, and frequently flaky or schistose in structure, and are traversed by numerous cracks and fissures in which quartz has accumulated, and, with it, gold in many instances. The rocks in which these auriferous quartz veins are generally found are those schists which are named from their predominating mineral chloritic, talcose, micaceous, or hornblendic; it is found less commonly in diorite, in porphyry, and sometimes in granite. These rocks often contain gold in very minute proportions, which becomes sometimes more prominent in the vicinity of a fissure or crack, but it is never present in quantities which would permit of the idea being entertained of its commercial extraction from this so-called "country" rock; in the intersecting quartz veins, however, gold is frequently found in paying quantities, and such veins constitute the "gold reefs" found in different parts of the world. Gold is never found in these veins in continuous bands, as is the case with other metalliferous deposits; but it occurs in patches and accumulations, here and there, in the vein; such patches are known as bunches, shoots, pipes, chimneys, according to the length, breadth, size, and position of the accumulation. In some cases veins are filled with pyrites instead of quartz, or sometimes, in fact very frequently, both are present, and the pyrites is found to contain gold; it then appears not to be so bunchy as when it exists in the quartz veins. I have seen in Colorado thick bands of auriferous pyrites, which, from their appearance in many adjacent mines, may be presumed to be many hundred yards in length, and apparently more or less continuous. Gold tellurides are also found in veins in Transylvania, in Hungary, and in Boulder County, Colorado.

Gold, however, does not exclusively occur in reefs; in fact, the largest supplies have been obtained from "placers," where it occurs in beds of sand or gravel, which have been, or are even now, the beds of rivers. Other instances are known where gold occurs in deposits consisting of fragments of rock cemented together by silicious material, forming what is known as breccias, or conglomerates, or puddingstone, or, in the Transvaal, as banket.

Both the auriferous sand and the banket owe their origin to the destruction—which is constantly going on now, and has been going on ever since the rocks have existed—of the auriferous rocks. The detritus, in the case of the sand, has been carried down the rocky slopes by streams of water, which have dissolved much of the rocky material, and carried away light particles, wearing away larger ones, and allowing the heavy gold and wear-resisting quartz to deposit themselves. In course of time the former has become concentrated in those parts of the river where the current has been interrupted by bends, &c., for the simple reason that the sand, being lighter, is to a large extent washed away by eddies of water which would not be sufficiently strong to move the heavier particles of the precious metal (the specific gravity of quartz is 2·65, while that of gold is about 19). Such accumulations are called "pockets." The "banket" deposits possibly originate in much the same manner, only the conditions being favourable, much of the detritus, which has become pulverised, and concentrated as regards gold, as in the case of the sand, has subsequently acted as a cement to the larger fragments, and so given rise to the present deposits.

There is still another form of deposit in which gold is found, and which is also derived from the destruction of older rocks. In this case the amount of water has been limited, and consequently the more refractory products of decomposition, instead of washing away to form banket or sand, remain on the spot or near it; moreover, they remain in great blocks permeated with vesicules and holes, which represent the positions previously occupied by the less refractory constituents, these having succumbed to the action of the various constituents of the atmosphere; that is to say, the moisture, the carbonic acid, and oxygen. The minerals left behind are principally quartz, some iron oxide, and gold, if present in the original rock; some of the gold will, however, dissolve. These spongy-looking deposits of ferruginous quartz are known as "gossan," and are generally found whenever the out-crop or the upper part of the lode is exposed to atmospheric action. If we take into consideration the enormous number of years during which these changes have been going on in nature, it is easy to realise that very extensive deposits of this description may have been brought into existence. They would, of course, be more localised than the banket deposits, which in their turn ought to be more localised than the alluvial or river deposits. The famous Mount Morgan mine in Queensland, Australia, is an instance of a deposit produced by atmospheric influences.

In alluvial deposits and in the various matrices the gold appears in many states of aggregation, which have received various names:—In nuggets, or pieces of irregular shape and of moderate size, in grains more or less crystalline, down to powder which consists of individual particles invisible to the naked eye; or it occurs as thin sheet gold, leaf gold, foliated gold, down to mere films of gold; and sometimes in long, thin aggregates of gold, such as that known as wire-gold, of moderate thickness, down to mere threads of gold.

Gold is found in all parts of the world. In Europe it is found in largest quantities in Transylvania, and in Hungary, where mines were worked by the Romans. It is also found in Spain, in North Italy on the northern slope of the Alps, from Monte Rosa and Simplon to Aosta, in Sweden, in Wales near Dolgelly, in Scotland near Leadhills, in Ireland in county Wicklow; whilst auriferous sands exist in the following amongst other rivers: Rhine, Rhone, Reuss, Aar, Danube, and many Cornish streams.

In Asia gold is found in the Ural Mountains, where it was probably mined by the Scythians; also in Siberia and in many other parts of Asia, notably India.

In Africa it occurs on the west coast, near Ashantee, known as the Gold Coast, and in the Transvaal, which is now so famous; it has been said that Matabele Land is one of the richest gold districts in the world. On the coast of Mozambique there are gold mines which are supposed to be the same which existed in Solomon's time under the name of mines of Ophir, which name has lately been applied to certain properties in that district, recently put on the London market. Gold also exists elsewhere in Africa.

In America, North, South, and Central, gold is very widely distributed. It is found in Mexico. In the United States, the gold mines of North Carolina, Virginia, Georgia, and South Carolina were once the great source of gold, but the discovery of gold in California in immense deposits soon eclipsed these and all other known gold deposits in the world; the subsequent discoveries in Australia, however, equalled them. Other States are gold producers—Colorado, Arizona, Idaho, Utah, some of the Eastern States, the newly created States Dakota and Montana, and the territories of Washington and Oregon. British Columbia and Vancouver's Island have gold—the former promises well for the future; so has Alaska; whilst gold is also found on the eastern side of Canada and in Nova Scotia. In Central America gold occurs in many places, including Honduras, Costa Rica, &c.

In South America, Brazil has long been famous for its gold mines; but gold is also found in the Argentine Republic, Venezuela, Colombia, and Guiana.

Australia is famous for its gold, and all who visited the Indian and Colonial Exhibition will remember the great arches built to represent the output from Victoria and New South Wales. It is also found in Queensland, South Australia, New Zealand, &c.

THE SPECTRUM OF THE ORION NEBULA.

DR. HUGGINS has kindly sent us an early copy of an important paper he has communicated to the Royal Society on the spectrum of the above nebula, with a copy of a photograph showing some twenty-five very sharply-defined lines in its spectrum, and in the spectrum of the stars of the trapezium. At least four groups of bright lines in the spectrum of these stars can be traced into the nebula for some little distance from the stars. Dr. Huggins says:—

"It is scarcely necessary to state the importance of this observation as showing that these stars of the trapezium are not merely optically connected with the nebula, but are physically bound up with it, and are very probably condensed out of the gaseous matter of the nebula. . . . The first group of six lines occurs between λ 4116 and 4167. The lines of this group do not extend far from the continuous star spectra, with the exception of two lines. These can be seen faintly in another photograph taken in 1889. Beyond there is a fainter group, probably of four lines a little beyond *h*. I am pretty sure that these lines extend into the nebula. The third group from λ 3896 to 3825, of which I have endeavoured to measure ten lines, is faint; but there is no doubt that the same lines are present in the adjoining nebular matter. There are two lines a little more refrangible than the strong line seen in 1882, at about λ 3709 and λ 3699. I have a suspicion of a faint group about this place, and also of another group on the less refrangible side of G."

Dr. Huggins stated in 1872, as the result of numerous direct comparisons of the brightest of the nebula lines with the brightest line in the spectrum of nitrogen, that the nebula line was "sensibly coincident with the middle of the less refrangible line of the double line of nitrogen."

In a still more critical examination of the position of the nebula line for the purpose of determining whether there was any indication of relative motions of the gaseous nebulæ in the line of sight, he found some experimental difficulty from the circumstance that the nebula line is narrow and defined while N_1 is nebulous, but he was fortunate in finding a more suitable fiducial line of comparison in a narrow line of lead which falls almost upon the middle of N_1. In December, 1872, he compared this line directly with N_1, and found it sufficiently near in position to serve as a fiducial line of comparison.

Six other gaseous nebulæ were also examined, each on several nights, with the result that "in no instance was any change of relative position of the nebula line and the lead line detected."

In the simultaneous observation of the nebula line and the lead line it was found that if the lead line was made rather less bright than the line of the nebula, the small excess of apparent breadth of this latter line appeared to overlap the lead line to a very small amount on its less refrangible side, so that the more refrangible sides of the two lines appeared to be in a straight line across the spectrum. The closeness of position of the two lines was shown by the observation that when the line of the nebula passed across the field of the spectroscope, and the lead line was thrown in, nothing was seen but an increase in brightness of the nebula line. By comparing the end of the nebula line near the trapezium, where it is refined to a point, he estimated that the difference of position of the middle of the lead line and that of the nebula line might be possibly from λ 0000·2 to λ 0000·3. Some recent measures of the position of the lead line with the middle of N_1 show that the lead line is about λ 0000·12 more refrangible.

These direct comparisons of the nebula line with the lead line confirmed his former conclusion, that the brightest line in the gaseous nebulæ is very near N_1, when seen under a dispersion equal to nearly eight prisms of 60, namely, 36° 25′ from A to H.

Dr. Huggins's final determination of the wave-length of the brightest nebula line is λ 5004·6 to λ 5004·8.

In a paper read before the Royal Society in 1887, Mr. Lockyer says:—"Only seven lines in all have been recorded up to the present in the spectra of nebulæ, three of which coincide with lines in the spectrum of hydrogen and three correspond to lines in magnesium. The magnesium lines represented are the ultra-violet low-temperature lines at 373, the line at 470, and the remnant of the magnesium fluting at 500, the brightest part of the spectrum at the temperature of the Bunsen burner."

As Mr. Lockyer's theory, that the nebulæ are composed of sparse meteorites, the collisions of which bring about a rise of temperature sufficient to render luminous one of their chief constituents, magnesium, is based upon the above statement that the nebula lines correspond with the magnesium fluting. Dr. Huggins thought it desirable, on account of the "grave theoretical conclusions which Mr. Lockyer had based on his statement of their coincidence and on that of the photographic line about 3730 with the next strongest group of the burning magnesium spectrum, to undertake the laborious task of comparing, with the necessary care and precautions, the nebula line directly, in the spectroscope attached to the telescope, with the spectrum of burning magnesium.

Dr. Huggins says: "It will be seen by a reference to Mr. Lockyer's statement that he escaped from the difficulty of the known difference in position of the nebula line and that of the magnesium-flame band, by having taken the wave-lengths to three figures only."

Arrangements were made by which the light from burning magnesium was thrown into the telescope from the side and then reflected down, under conditions similar with the light from the nebula, upon the slit of the spectroscope. By this arrangement any flexure in the tube connecting the spectroscope with the telescope would affect both spectra alike. The direct comparison was successfully made on March 6. But Dr. Huggins failed to find the coincidence in position asserted, and the nebula lines are sharp, and show no winged character corresponding with the flutings of the magnesian spectrum.

The positions of the lines observed and photographed in the spectrum of the nebula are:—

Line measured by Dr. Copeland, probably D_3 .	λ 5874·0
Brightest line	5004·6 to 5004·8
Second line	4957·0
Third line, Hβ	4860·7
Fourth line, Hγ	4340·1
Line measured by Dr. Copeland . . .	4476·0
Strong line in photographs 1882 and 1888 about	3724·0
Line in photographs 1888 . . . . „	3709·0
„ „ . „	3699·0
Photograph 1889. 1st pair . „	3752·0
„	3741·0

7. Ramified Lightning.—Taken at Meudon, near Paris, on June 24th, 1888, by E. L. TROUVELOT.

8. Sinuous Lightning.—Taken on the Alleghany Mountains, U.S., on August 2nd, 1887, by L. S. CLARKE.

CUNNINGHAM & LAWRENCE. COLLEGE HILL, E.C

LIGHTNING PHOTOGRAPHS.

Photograph 1889.	2nd pair	about . .	λ 3285·0
		,, . .	3275·0
,, ,,	Line at	,, . .	3060·0
,, ,,	3rd pair	,, . .	3053·0
		,, . .	3047·0
Photograph 1888 :	Lines across star spectra, 1st group .	,, . .	4116·0
		,, . .	4123·0
		,, . .	4130·0
		,, . .	4142·0
		,, . .	4154·0
		,, . .	4167·0
	2nd group	approximate	3998·0
		,,	3988·0
		,,	3975·0
		,,	3959·0
	3rd group	,,	3896·0
		,,	3887·0
		,,	3878·0
		,,	3870·0
		,,	3859·0
		,,	3854·0
		,,	3848·0
		,,	3842·0
		,,	3832·0
		,,	3825·0

As to the chemical significance of the lines he has observed, Dr. Huggins says:

"Until I can obtain more photographs taken on different parts of the nebula, I wish to be understood to speak on this point with much hesitation, and provisionally only. We know certainly that two of the lines are produced by hydrogen. The fineness of these lines points to a high temperature and condition of great tenuity of the hydrogen from which the light was emitted. This condition of the hydrogen may give us a clue as to the probable interpretation of the other lines. These may come from substances of very low vapour-density, and under molecular conditions which are consistent with a high temperature. It is in accordance with this view that the recent measures of Dr. Copeland, since confirmed by Mr. Taylor, show with great probability that the line known as D_3, which has been supposed to indicate some substance of very low vapour-density, which shows itself only at the hottest region of the sun, is present in the nebula spectrum. The great simplicity of the three pairs of lines seen in the photograph of 1889 suggests a substance of a similar chemical nature.

"If hydrogen can exist at half its usual vapour-density, with a molecule of one atom only, we might possibly expect to find it in some of these bodies, but at present we do not know what its spectrum would be in such a condition. It may be possibly that it is in molecular states of our elements other than those we are acquainted with that we may have to look for an interpretation of some of the lines of these bodies."

PHOTOGRAPHS OF LIGHTNING.

By W. Marriott and A. C. Ranyard.

EVERY one who reads this has probably experienced, at some time or other, strange feelings of awe during the passage of a great thunderstorm. Our want of knowledge with respect to the behaviour of lightning adds to the terror. As the thunder crashes and rolls we feel that we are in the presence of unknown forces. Some people even close all shutters and doors, and shut themselves up in fear and dread of observing the storm. Those, however, who have had the courage to watch a thunderstorm have found that they are not blinded by the lightning, though they have frequently learnt very little as to the form of the flashes or the direction in which they travel.

The duration of a lightning flash is inconceivably small, being in some instances about a millionth part of a second. This is proved by the observation of radial lines on a rapidly rotating disc, which appear absolutely stationary when illuminated by a lightning flash. The eye is dazed by the sudden brightness, and is unable to follow the flash, or to determine whether it proceeds from the clouds to the earth or from the earth to the clouds. The generally received idea has been that the lightning passes from the clouds to the earth; it is, however, probable that it most frequently proceeds from the earth to the clouds.

It is popularly supposed that lightning takes the zigzag course so frequently depicted by artists, but, as will be seen from the plates accompanying this article, lightning generally pursues a curious sinuous course. Mr. James Nasmyth, who was perhaps the first to give a correct picture of natural

Fig. 1.—Artists' Lightning after Nasmyth.

Fig. 2.—Natural Lightning, according to Nasmyth.

Fig. 3.—Branched Lightning, according to Nasmyth.

lightning, believed the error of the artists originated in the form given to the thunderbolts in the hand of Jupiter as sculptured by the Greeks. In a paper communicated to the British Association in 1856, Mr. Nasmyth stated that he had never observed the zigzag form of lightning usually represented in works of art (as indicated in fig. 1), but that

the true natural form of a flash of lightning was more correctly represented by a crooked line as in fig. 2, and that it occasionally assumed the forked or branched form indicated in fig. 3. Any one who compares these woodcuts (which were those used in Mr. Nasmyth's article, and have been kindly lent by the British Association for the illustration of this paper) with the photographs of flashes of lightning shown on the plates will at once see what a keen observer Mr. Nasmyth must have been.

Two years ago the Council of the Royal Meteorological Society issued a circular stating that they desired to collect photographs of flashes of lightning, as they believed much valuable information might be obtained from them respecting some of the forms which lightning occasionally assumes. It had at times been reported at the meetings that ball lightning had been seen slowly moving through the air, occasionally entering rooms and bursting, and it was hoped that these photographs would throw some light upon the subject.

Nearly one hundred photographs from all parts of the world have been received in answer to this appeal, but no photographs of the ball lightning described have as yet come to hand. The photographs received were first shown at the annual exhibition of the R. Meteorological Society in March, 1888, and subsequently at the conversazione of the Royal Society, and on each occasion they attracted much attention.

In June last the Society published a report on these photographs, in which a classification was made of some of the various forms of lightning flashes. The six most typical forms are :—Stream, sinuous, ramified, meandering, beaded or chapletted, and ribbon lightning.

Some of the more remarkable photographs are reproduced on the accompanying plates by kind permission of the Council of the Society.

Plate I. contains six of the photographs taken in London during the terrific and prolonged thunderstorm which burst over the metropolis on the evening of August 17, 1887. This storm is described as being the most severe that has occurred in London for very many years past—the lightning was exceedingly vivid and brilliant, and the thunder loud and continuous. Certainly these six photographs show that the lightning assumed strange forms, and pursued very erratic and meandering paths. We shall refer to these photographs after describing those on Plates II. and III.

No. 7 on Plate II. is an example of ramified lightning, the flash dividing and branching off in various directions. The flash at the right hand of the photograph appears to have twisted and turned about in a curious manner. This photograph was taken by Mons. E. L. Trouvelot, at Meudon, near Paris, on June 24, 1888. No. 11 is another example of ramified lightning, in which little flashes branch out from the main flash, though we have no evidence as to whether these fibres branch off from, or run into, the main flash. It will be noticed that in most instances the lower or earth end of the flash is brightest.

No. 8 shows a grand display of sinuous flashes, the lightning also illuminating the thunder-clouds. This photograph was taken by Mr. L. S. Clarke from the top of the Alleghany Mountains on August 2, 1887. No. 11 is also an example of sinuous lightning. In this photograph several flashes appear to follow almost the same path, though, as the plate was exposed for some time, we have no means of knowing whether these flashes occurred almost simultaneously or whether there was a considerable interval between each. Neither have we any knowledge as to the distance of the lightning from the camera. Mr. H. C. Russell, of the Sydney Observatory, has just sent over a photograph which shows three or four flashes of lightning much closer together than those in No. 11. He was able to determine the position of the thunderstorm, and found that the lightning was about twenty-six miles distant. The flashes may consequently have been some distance apart.

No. 9 is an example of the meandering and beaded forms of lightning. The main flash seems to wander about in an aimless sort of way, while in the central flash in the upper part of the photograph there appear to be two bright spots. It has been suggested that these bright spots are caused by the flash at those points moving directly towards, or away from, the camera, and consequently giving a somewhat longer exposure at these spots.

Nos. 12 and 13 are examples of the ribbon form of lightning, in which the flash has the appearance of a piece of ribbon being waved in the air, the front edge being brighter than the other part. Nos. 1 and 2 on Plate I. have also the same appearance but in a more marked degree.

Several suggestions have been made as to the probable cause of this ribbon-like appearance. One suggestion is that the second fainter image is formed by internal reflection from the back of the glass plate. This duplication, however, is not confined to glass negatives, but occurs on paper negatives as well. No. 13 was taken on a sensitive paper film. Another suggestion is that the double image is formed by the internal reflections of doublet lenses. A third suggestion is that the lines are caused by the shaking of the camera in the direction of the folds of the ribbon. None of these suggestions seem, however, to be borne out by a close examination of the photographs. If the streaks were due to reflections from the surfaces of the photographic lenses, we should expect to find a symmetrical arrangement of such ghosts with respect to the axis of the lenses or the centre of the plate; but there is clearly nothing of the kind. It will be noticed that the delicate lace-like filaments in photograph No. 1 are not quite parallel on different parts of the plate, but the want of parallelism of the filaments seems to be rather due to perspective than to a shift of the plate; this is even more noticeable on photographs 12 and 13. If the camera could be shifted rapidly enough during the minute fraction of a second which the lightning flash lasts to cause such traces on the plate, all the tracks would be parallel to one another or tangential about a centre round which the camera had moved; but there is clearly no such arrangement, and the brighter streaks do not correspond with brighter spots on the edge of the ribbon, as would be the case if they were due to a shift of the plate. Recent experiments by Mr. J. Wimshurst with his electrical influence machine have conclusively shown that in the case of such sparks as can be produced in the laboratory, a rapid motion of the plate will not give rise to streaks. Mr. Wimshurst has made a dark slide for his camera, to which is fitted a train of clockwork carrying a disc, upon which is an arrangement for holding the sensitive plate. When all is complete for photographing a flash, the clockwork is wound up, the sensitive plate then rapidly acquires great velocity, which at the maximum reaches 2,500 revolutions per minute, and the plate rotating at this speed, the spark is photographed. The photographs thus obtained in no way indicate movement in the sensitive plate, the flashes being quite sharp and distinct.

It will be noticed that the brighter streaks proceed from parts of the ribbon edge where there is a sudden change in direction of the stream—possibly the appearance of increased brightness may be merely an optical illusion caused by greater thickness of the stream at these points as seen in projection. On this supposition the flash would consist of a bright sinuous band, with a broader and fainter band running parallel with it. The flash in photograph No. 6, when examined with a lens, is seen to be of the same ribbon-like character, the plane of the ribbon remaining

apparently parallel to a fixed line in space through the whole of the loop and the convolutions of the knot or contorted region where the two flashes join and branch off.

A similar appearance of parallelism of the striæ to a fixed line may be recognised in the other photographs of ribbon flashes; possibly the striæ always make tho same angle with the horizon, for there is some doubt as to whether photographs Nos. 1 and 2 are the right way up upon the page. Photographs of such contorted ribbon flashes from two points would enable us to determine whether there is any connection between the direction of the striæ or folds and the earth's magnetic axis, or whether the direction is determined by the prevailing wind or other meteorological conditions. Similar folds are shown in many drawings of the Aurora. Some good woodcuts of Auroral curtains have recently appeared in the German periodical, "Himmel und Erde," according to which the Auroral striæ are nearly perpendicular to the horizon. But the drawings were made in the neighbourhood of the earth's magnetic pole.

If No. 4 be examined carefully it will be seen that in addition to several ordinary white flashes, there is a *dark* flash of precisely the same character as the bright flashes. A suggestion has been made that this may be the result of a very bright flash so over-exposing the plate as to produce the well-known reversal effect by over-exposure, as when the disc of the sun appears black on a positive print instead of white. Professor Stokes, who has examined the photograph, says: "The dark flash was perhaps produced by a previous flash before the cap over the lens was taken off, which had produced nitrous oxide along its track. The actual flash photographed would then illuminate the background of cloud, but this light could not pass through the nitrous oxide, and thus would give a dark track due to absorption." If the dark flash were due to over-exposure, its edges and fainter parts would be bright, but there is no such evidence of photographic reversal having taken place. In the case of the curtain form of flash, No. 2, with a dark line running along it parallel to the bright edge, this may possibly be due to a previous curtain flash in front which produced the nitrous oxide gas which cut out the light of the second flash.

It is to be hoped that some one will be able to make experiments to test this theory. Professor Stokes has suggested that during a thunderstorm in the daytime a camera should be charged and the cap taken off the lens just after a flash has been seen; then, according to his theory, a dead flash should show itself on the plate.

More than one photograph of such a flash would be of great interest in showing how the dead flash disappears. The tracks left by meteors in the upper air occasionally remain visible for half an hour or more, and are seen to be bent and drifted by the wind. The behaviour of the dark track might, perhaps, give some clue as to whether it is due to the smoke of burnt dust particles floating in the air, or whether it behaves as a column of gas might be expected to behave while being lost by diffusion into the surrounding air. If the dark column is due to smoke a photograph taken with a large double image prism, placed in front of the camera lens, would, if the column of smoke were illuminated by a side light, probably show a difference in brightness of tho two images, due to polarisation of the light dispersed by the smoke particles, and we should expect to find such a column darker in the lower air and in cities where inflammable dust exists than in the case of lightning photographed from a mountain side; but, during the thunderstorm season, the air in the open country is frequently charged with pollen to a considerable altitude. It might be well to test the character of the dust by burning the sediment from rain collected during the storm.

Nos. 3, 5, and 6 are further examples of the meandering form of lightning. No. 6, which was taken at Clapham by Mr. J. Guardia, is not only a very good specimen of the ribbon-type, but is a remarkable example of the strange course sometimes taken by lightning. The flash seems to have twisted and turned about in a very curious manner, and to have apparently taken an oval course, and come back upon itself. It would have been very interesting if we could have had another photograph of this same flash taken from a different point of view. We could then have fixed the position of the flash, and ascertained its length. The length of a lightning flash may be some miles in extent. Mr. L. P. Muirhead states that during the thunderstorm which occurred at Glasgow on May 19, 1888, he observed a very long and bright flash which by the Ordnance map he judged to have been six miles long.

There is a form of lightning of which at present no photographs have been obtained, viz., ball or globular lightning. This appears as a ball or globe of fire, varying in apparent size from a cricket ball to a football; it moves very slowly—in fact, some people have stated that they have been able to get out of its way—and, as a rule, finally explodes with great violence. Arago, in his "Meteorological Essays," gives several accounts of this phenomenon. Thus at Milan in 1841, one of these globes moved along a street so slowly that the spectators walked after it to watch it, and the narrator, who first observed it from a window, ran downstairs, and saw it for three minutes before it struck the cross on a church steeple and disappeared. Such statements are very frequent, and there is no reason why they should be doubted. Dr. Tripe, of Hackney, says that on July 11, 1874, while watching a thunderstorm, he saw a large ball of fire rise apparently about a mile distant from behind some low houses. It first rose slowly then accelerated its pace as it ascended, and gradually acquired a very rapid motion. When it had risen about 45°, it started off at an acute angle towards the west, with such rapidity as to produce the appearance of a flash of forked lightning.

A very remarkable account of globular lightning in the Glendowan Mountains, in county Donegal, was reported by Mr. M. Fitzgerald some years ago to the Royal Meteorological Society. He says:—"From its first appearance till it buried itself could not have been more than twenty minutes, during which time it travelled leisurely, as if floating with an undulatory motion through the air, over one mile. It appeared at first to be a bright red globular ball of fire, about two feet in diameter, but its bulk became rapidly less, particularly after each dip in the soil, so that it appeared not more than three inches in diameter when it finally vanished."

From what has been already said, it will be seen that the photographs have brought out several facts about lightning which had hitherto been entirely unsuspected. Additional photographs would probably still further increase our knowledge, and also confirm or disprove some of the conclusions already arrived at. As the thunderstorm season is now approaching, it is to be hoped that many photographers will take up this interesting subject and secure a goodly number of photographs of flashes of lightning. As the plate can only be exposed at night, the lens should be focussed for some distant object during the daytime, and a mark made on the camera, so that it can be easily adjusted at night.

A rapid rectilinear lens with full aperture should be used, and if possible some building or landmark should be included on the plate to give the position of the horizon. The exact position and aspect of the camera should always be carefully recorded, as well as the precise time of any flash that may come within the field of view. These particulars are very

necessary, as if the same flash were photographed from two or more points, we should be able to fix the position of the flash in the air, and determine its size. The time interval between the lightning flash and the thunder should always be noted, as this will afford the means of ascertaining how far off the lightning is. For all practical purposes we may allow 5 seconds to a mile. It is desirable, if possible, not to have more than one flash upon a plate. Particulars should also be recorded of the direction of the storm, the movement of clouds, the direction and force of the wind, &c.

More is likely to be learnt with respect to the structure of these ribbon and dark flashes if they can be photographed on a large scale. There is a limit to the size of the camera which can be conveniently used, but it is evident that the nearer the flash the larger will be the angle that it subtends upon the plate. For this reason it is not photographs of flashes upon the horizon that are so much needed as photographs taken in the midst of a storm. With a storm immediately overhead, the points of reference necessary for determining the parallax and height of the flash by comparison with another photograph might be obtained by noting the place of the camera and including chimneys in the picture, or telegraph-wires or strings stretching across the sky.

The subject of lightning flashes is only part of the investigation which the R. Meteorological Society has on hand in connection with thunderstorms. The Society is collecting observations on British hail and thunderstorms with the view of gaining some knowledge of the nature and causes of the different kinds of thunderstorms, and discovering the localities where hail and thunder are most frequent and destructive. Much valuable information has been already received which is now being collated and discussed. Mr. Marriott would be glad if the readers of KNOWLEDGE would favour him with observations made during thunderstorms; even simple records of the times when thunder, lightning, rain and hail begin and end, and when they are loudest, brightest, or heaviest, would be acceptable. Notices of distant or sheet lightning, with the time of its occurrence and the direction in which it is seen, are also of service in tracing the path of a thunderstorm. This was well illustrated in the case of the storm which occurred on the night of May 18, 1888. This thunderstorm came up from the English Channel about 8 P.M., passed across the country in a north by west direction, and reached the Firth of Forth by 4 A.M. on the 19th. The distance traversed was over 400 miles, the rate of progression being 50 miles an hour. Many observers in various parts of the country only saw lightning; but where they gave the time and direction in which the lightning was seen, it was found that these agreed precisely with the positions of the thunderstorm at those times, although the observers, in two cases at least, were more than 100 miles from the storm.

The Meteorological Society is anxious to secure as large a collection as possible of lightning photographs. Readers of this paper who wish to assist in the research should forward the original negatives if possible, or, if not, prints from them, to Mr. W. Marriott, secretary of the R. Meteorological Society, 30 Great George Street, Westminster, S.W. Any other information bearing on the subject of thunderstorms will also be welcomed by him. It would be well to mark the top of the sensitive plates before they are put into the dark slide for exposure, so that there may be no doubt as to the orientation of the picture if no buildings or trees are included. But pictures with reference marks, from which the parallax and the actual size and position of the flash can be determined, cannot be too much insisted upon. The time of the flash, and the interval between it and the thunder, should, in every instance, be noted, and the observer's watch should be compared as soon after the storm as possible with post-office time.

TOTAL SOLAR ECLIPSE OF 1889.

JANUARY 1.

By A. C. RANYARD.

PHOTOGRAPH No. 14 on Plate III. is copied from a transparency on a flexible film, which has been kindly sent me by Professor W. H. Pickering. The transparency was made direct from the original negative, and shows a great deal more coronal structure than is reproduced in our illustration. The difference of brightness between the coronal details and the background on which they are seen is so slight that there is always difficulty in reproducing them, and copies of coronal photographs are always much inferior to originals in showing such details.

The original negative was taken at Willow, California, with a lens of thirteen inches aperture, and an exposure of ten seconds on a Carbutt A plate. It is the largest photograph of the corona which has yet been taken in the primary focus of an instrument, though in the early days of eclipse photography more than one photograph on a still larger scale was taken in the secondary focus of instruments, but the extent of corona shown in such early photographs was very small as compared with that shown in Professor Pickering's photograph. The sun's axis is as nearly as possible vertical on the page, the north pole being uppermost. It will be noticed that this corona is not quite symmetrical with respect to the sun's axis, the chief equatorial extension being a little northward of the solar equator on the west side, and towards the south on the east or left-hand side of the picture. There has been a similar want of exact symmetry with respect to the sun's axis in other coronas. The position of the sun's axis is derived from the observation of the motion of sun-spots in the equatorial regions; but the corona, both in its equatorial regions and polar rifts, has in several instances shown a tendency to symmetry with respect to a line which does not correspond by some 10° or 15° with the axis of rotation as derived from the observation of sun spots.

In the transparency sent by Professor Pickering, four synclinal groups of structure are distinctly shown, symmetrically placed with respect to the general axis of symmetry of the corona. The northern edges of the two northern synclinal groups and the southern edges of the two southern synclinal groups show marked contrary flexure. The rays bounding the polar rifts are greatly inclined to the radial at the point where they spring from the sun's limb, as in the case of the 1871 corona, and are concave towards the axis of the synclinal groups in their lower regions and convex above; a similar contrary flexure is noticeable in the rays bounding the polar rifts of the 1871 corona. The corona of January 1889 corresponds to a period of solar quiescence, as measured by sun-spot disturbances. It is similar in many respects to other coronas, which have been observed at other periods of sun-spot minima. There is great equatorial extension of the corona, and there are broad polar rifts. On the transparency sent over by Professor Pickering, though a great many curved rays are visible, no great tree-formed structures, with spreading heads and narrow stems, can be recognised. Such structures seem to be associated with periods of greater sun-spot development.

9 Meandering and Beaded Lightning.—Taken at Rougemont, near Tours, on May 26th, 1886, by H. Schleusner and E. B. Vignoles.

12. Ribbon Lightning.—Taken on Board H.M.S. "Neptune," between Madeira and Gibraltar, on November 14th, 1884, by Dr. Puddicombe.

wich, Connecticut, in July, 1886, by Dr. Pippard.

13. Flash of Ribbon Lightning, at Bournemouth.

11. Ramified Lightning.—Taken at Philadelphia, on July 22nd, 1887, by W. N. Jennings.

14. Corona of 1st January, 1889, from photograph taken by Prof. W. H. Pickering, at Willow, California.

CUNNINGHAM & LAWRENCE, COLLEGE HILL, E.C.

LIGHTNING PHOTOGRAPHS

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

ON THE SYSTEM OF SHORTHAND EMPLOYED BY ABRAHAM SHARP.

To the Editor of KNOWLEDGE.

SIR,—In your interesting notice of Mr. Cudworth's "Life and Correspondence of Abraham Sharp" in the March number of KNOWLEDGE you have given a facsimile of the end of a letter from Flamsteed, and of the draft of Sharp's answer to it which is written in shorthand.

Mr. Cudworth mentions that in Sharp's note-books there are many of such shorthand notes, but that he had quite failed in his attempts to decipher them, and he states that Mr. Baily, before him, had been equally unsuccessful. A correspondent of yours in the same number of KNOWLEDGE mentions that from the study of a specimen of Sharp's shorthand writing on a letter dated June 1705, he had succeeded in mastering the alphabet and most of the symbols, but he seems not to be aware that the system employed is one by a known author. Although I have no pretension to be an expert in shorthand, I happen to be in a position to clear up this matter, and I think that it may perhaps be interesting to some of your readers if I explain briefly the circumstances that led me to acquire the information which I am now able to give. Several years ago, when examining the Newton MSS. belonging to the Earl of Portsmouth, a portion of which he has presented to the University of Cambridge, I found a small note-book of Newton's containing, among other things, two or three pages of memoranda written in shorthand and numbered in consecutive order, all of them belonging to the year 1662, which was written in plain figures. This was the year immediately following that in which Newton came into residence in Trinity College.

Naturally I was curious to decipher these memoranda of Newton's, and I had great hopes that by consulting the extensive collection of ancient books on shorthand, made by Pepys, and preserved in the Pepysian Library, I might be enabled to do so. The librarian of Magdalene College most kindly allowed me to examine these books and I found, as I expected, that one of them contained an explanation of the identical system of shorthand which had been employed by Newton. After a little study I was able to read every word which occurred in these memoranda, which, however, were all of a private, personal character, having no reference to science.

The author of this system of shorthand was Thomas Shelton, and the title which he gave to it was Zeiglographia. I have a copy of this book dated in 1659, but I believe that the work went through many editions. The same author published an earlier work on the same subject, with the title Tachygraphy, my copy of which has the date 1645. The systems explained in these works are quite similar in principle, but the alphabets are entirely different. On referring to Abraham Sharp's shorthand letter given in KNOWLEDGE, I saw that the alphabet was the same as that of Zeiglographia, and I readily made out that the letter referred to the fright caused by the rebels in 1715 passing in the neighbourhood of Bradford, where Sharp was then residing, and that it was in fact the draft of the letter which appears under the date October 19, 1715.—Yours faithfully,

J. C. ADAMS.

Observatory, Cambridge.

To the Editor of KNOWLEDGE.

DEAR SIR,—I am obliged for the opportunity afforded me of reading Professor Adams's interesting letter on the shorthand used by Abraham Sharp. My letter in KNOWLEDGE, March 1, in which I stated I had partially deciphered three of Sharp's letters to Yarwell from the shorthand copy is referred to, under the impression that I was unaware of the system used. This was not the case however. I intended to imply that I knew it by stating that it was "a system of which very little was known," and I told you in conversation that I was acquainted with the system. It is really Coles's, not Shelton's, but the two are so alike that one needs to be intimately familiar with them to detect the difference. I know something of over two hundred systems, but generally attack an old shorthand problem as I would a cryptogram, without thinking of systems. I saw at once that it was on the lines of Thomas Shelton's Zeiglography (1650), and that it was from Elisha Coles's adaptation of the same (1674). This was corroborated on consulting the only accessible edition—the tenth (1710), unfortunately a mutilated one. With this defective material to help me, I was able to send you on March 1 a complete transcription of the letters to Yarwell, and on March 7 a transcription of the shorthand facsimile of Sharp's letter to Flamsteed (*vide* KNOWLEDGE, April 1). A German friend to whom I had presented a copy of the New Testament, neatly written in Coles's shorthand, kindly returned it to me a few days after, but too late to serve me with the above transcription.

On reference to my "Bibliography of Shorthand" (1887), there will be found among its 5,000 items of shorthand books, pamphlets, MSS., &c., in English and Latin, thirty-seven entries under "Thomas Shelton," but only three entries to "Elisha Coles."

Most of the old shorthand systems are similar in their alphabets, and the signs are easily recognised, but the mere knowledge of an alphabet will not go far in the decipherment of letters of the seventeenth and eighteenth centuries. There are complex arrangements for unwritten but indicated vowels, tables of complete and broken consonants, lists of prefixes and terminations, grammalogues, arbitraries and symbols, which block the decipherer's course. Coles made many additions to Shelton's Zeiglography, notably a neatly engraved table of 500 "symbolicalls," and a table of "our most usuall words," 240 in number—a great improvement on Shelton's limited system.

The greatest difficulty in deciphering old shorthand notes arises from the duplex forms of signs for consonants and vowels, words and phrases of the most opposite meaning having similar and even identical outlines. For instance, in my transcript of the letter to Flamsteed I took a sign, *aw*, or *alw*, for "allow," and now find it should be *ac*, for "acknowledge," which also stands in Coles's system for "account" and "according."

To-day, for the first time, I have the use of a copy of Mr. Cudworth's "Life of Abraham Sharp," and have examined the letter of October 19 referred to by Professor Adams, which appears to be a copy of the original long-hand letter to Flamsteed, of which, in KNOWLEDGE, March 1, you had a facsimile of Sharp's shorthand notes. I gave the date January 19, 1715–16; and this must be correct, as the letter was evidently written a few weeks after the taking of Preston by the Royal troops on November 13, 1715. It was in the well-known Derwentwater rebellion. There are several differences between the long-hand copy and the shorthand transcription. Beyond those variations of mine, due chiefly to the duplex outlines already mentioned, there are other mistakes and omissions in the long-hand copy which I cannot account for, except on the assumption of

misreadings by the long-hand transcriber, or actual variations.

The two shorthand systems of Shelton, Tachygraphy (1641) and Zeiglography (1650), although very different from each other, seem to have been held in great repute among the scholars and divines of the seventeenth century, even long after Rich's system (properly Cartwright's) had become popular. Shelton's Tachygraphy was used by Pepys in his well-known diary and correspondence, although when the Rev. J. Smith deciphered the original shorthand MSS. for Lord Braybrooke, he was under the impression that it was Rich's system. Archbishop Sharp (1642-1673), a supposed cousin of Abraham Sharp, wrote shorthand from his earliest to his latest years. His father, the drysalter, had it taught to him at a Bradford school. The system was probably Shelton's Zeiglography. All his works were written in shorthand, and the diary of his life from 1702 to 1713 was transcribed by his son, the Archdeacon, "Tom Sharp," the notice of whose study of an uncouth system of shorthand along with his friend Byrom is so well known. Archbishop Sharp had the reputation of preaching by heart, or making slight use of notes, when the fact was his sermon—written in shorthand—was before him, so disposed that he could look off and on, and with transient glances catch the sentences as required, giving meanwhile life and zeal to his utterances.

It is not generally known what a number of famous men of old times used the art of shorthand as an assistance to study or for official purposes. I may mention a few names without placing them in strict chronological order:—Roger Williams, the Puritan, founder of the State of Rhode Island, who wrote shorthand for Sir Edward Coke; Bishop Wilkins; Sir Henry Nicholas, secretary of Charles I. and II.; Bishop Jewel, who wrote in his own Tachygraphy at the trial of Ridley and Latimer; Elias Ashmole; Archbishop Secker; Sir Isaac Newton, who used Shelton's system; Dr. Hartlib; Dalgarno; Dr. Wallis; Dr. Holder; Defoe, who reported the speeches of Fletcher of Saltoun, Seton, and other Scottish patriots in the Scottish Parliament of 1669; Pepys; John Evelyn; Dr. Hartley; Franklin; Dr. Kippis; Dr. Darwin; Dr. Aikin; Dr. Fordyce; Doddridge; Sir Henry Cavendish; John Sturt, the engraver; Clement Walker, of Lilburn's time; Le Sieur Ramsay; Strype; Van Hove; Dr. Crutziger, who reported the disputations of Luther, Eck, and Melanchthon; Noah Bridges; Boerhave; Violi, who noted Savonarola's orations; Charles I. in correspondence with the Marquis of Worcester; Morrice, General Monk's secretary; Sir Henry Wotton; Cardinal Wolsey; Burnet; Rushworth, of the "Historical Collections"; Dr. Chamberlain, of "Anodyne necklace reputation"; Pierre Carpentier; John Locke; Holyoke, the early Harvard President; Lodwick; Archbishop Laud; Judge Sewall, the Puritan; Archbishop Usher; Lord Dartmouth; Lord Chancellor King; Horne Tooke; John and Charles Wesley; Dr. Watts; Dr. Blair; Enfield; Dr. Barbauld; Philip Gibbs; Priestley; Professors Gilbert and James Robertson; Job Orton; Hugh Farmer; Philip Holland; Dr. Caleb Ashworth; Dr. Samuel Clarke; Richard Baxter; Breithaupt; Wachter; Boswell; Jennings; Stackhouse; Dr. Mavor; and Gibbon. I wonder how many shorthand MSS. of one or other of these celebrities would be discovered if public libraries and private collections were thoroughly ransacked.

With respect to the shorthand notes of Sir Isaac Newton, which Professor Adams has deciphered, I have no doubt that he would find, if he published them, that a wide interest was taken in even small and personal details of the life of such a man.—Yours faithfully,

May 23, 1889. John Westby-Gibson.

INSECT SWARMS IN SOUTH AMERICA.

To the Editor of Knowledge.

Rio de Janeiro: April 20, 1889.

Dear Sir,—I beg to enclose a translation of a newspaper extract, which may be of interest to some of your readers.—Yours truly, G. W. Nicolls.

"On March 25, at Buenos Ayres, an enormous quantity of moths was noticed flying about in the evening. At night there fell upon the city, like fine rain, such an unprecedented invasion of small flies that in some places the passers-by were obliged to run. In the theatres, cafés, houses, and streets it was impossible to go a step save through legions of these insects. Some one, out of curiosity, having counted 20,000 in a square vara (about 44 inches), calculated that there could not have fallen less than 500 thousand millions over the whole city. Such a phenomenon is quite unheard of in the locality."

DOUBLE STARS.

To the Editor of Knowledge.

Sir,—I ask permission to make a remark or two in reply to your editorial comments on my paper on the above subject. As to the blue stars referred to, I am not familiar with them, but Sir John Herschel, who spent some time at the Cape, must have known them, and could not have regarded them as possessing the decided blue tint exhibited by the fainter of many pairs of stars. The colours of stars, however, is a subject on which different observers frequently differ, and I believe that the supposed changes in the colours of certain stars chiefly arise from this cause. With regard to the majority of stars with sensible parallax being double, however, I cannot assent to your criticism. The thirty-four stars in Young's "General Astronomy" cannot be regarded as stars with a sensible parallax. In two of them the only parallaxes given are negative, and both of these are single stars, viz. Betelgeuse and α Cygni. Two other fine single stars, Arcturus and Vega, have, according to the latest determination (Elkin's), insensible parallaxes (0·018″ and 0·034″, both figures being less than the probable error). In several other cases the parallaxes are almost equally small, and, where they are more considerable, they usually depend on the observations of a single astronomer sometimes made before the difficulties and uncertainties of such measurements were fully known. If we mean by near stars, those for which a parallax exceeding 0·1″ has been found by two independent observers, and for which no parallax of less than 0·1″ has been found by any observer, I think the following list is nearly complete—α Centauri, 61 Cygni, Sirius, Procyon, Aldebaran, Altair, and o_2 Eridani. There may be others which I have overlooked. All of these are either certainly or probably double stars with the exception of Altair. The agreement in proper motion and parallax of the two components of 61 Cygni seems to me almost conclusive as to their physical connection.—I remain, truly yours, W. H. S. Monck.

Dublin: May 4, 1889.

P.S.—As to the evidences of physical connection afforded by the colours of double stars, I may cite Professor Young ("General Astronomy," p. 494):—"Not unfrequently the components of a double star present a fine contrast of colour, *never, however, in cases where they are nearly equal in magnitude*. It is a remarkable fact, as yet wholly unexplained, that when we have such a contrast of colour the tint of the smaller star always lies higher in the spectrum than that of the larger one. The larger one is *reddish or yellowish*, and the smaller *green or blue*, without a single exception, among the many hundreds of such tinted couples now known."

Such an arrangement as this cannot be the result of chance, and unless all very distant stars are green or blue, it must be the result of physical connection. W. H. S. M.

As to the nearer stars being mostly double, Mr. Monck goes even further than I do in rejecting small parallaxes as doubtful. There are fourteen stars in Professor Young's list with parallaxes all considerably over a tenth of a second, which Mr. Monck does not take into account because their parallax has only been determined by one observer. Of these fourteen, eleven are single and only three are double stars. Facts such as these are best illustrated by presenting them to the eye, and I have therefore made a diagram showing the distance of twenty stars with large parallaxes. The parallaxes adopted for this purpose are those given in Professor Young's list, with the addition of some of Dr. Elkin's determinations. The diagram shows six of the seven stars referred to by Mr. Monck, but have been equally weighted, and the probable errors adopted by the observers are not taken into account. It will be seen that out of the twenty stars in the diagram, lying within a distance corresponding to a parallax of an eighth of a second, seven are double, one is a triple, and twelve are single. If we count the sun as a single star, the proportion which double and triple stars together bear to single stars is as two to three, in this small region of space. I admit that our list of doubles is probably still very imperfect, but our list of near stars is probably still more imperfect. If the stars are evenly distributed in space, we should expect to find seven times as many stars between the first and second concentric circles in the diagram as within the first circle, for the two circles correspond to spheres whose volumes are as one and eight, and there should be fifty-six times as many stars between the second and third circle as within the first circle, or seven times as many as within the sphere corresponding to the second circle. There is evidently

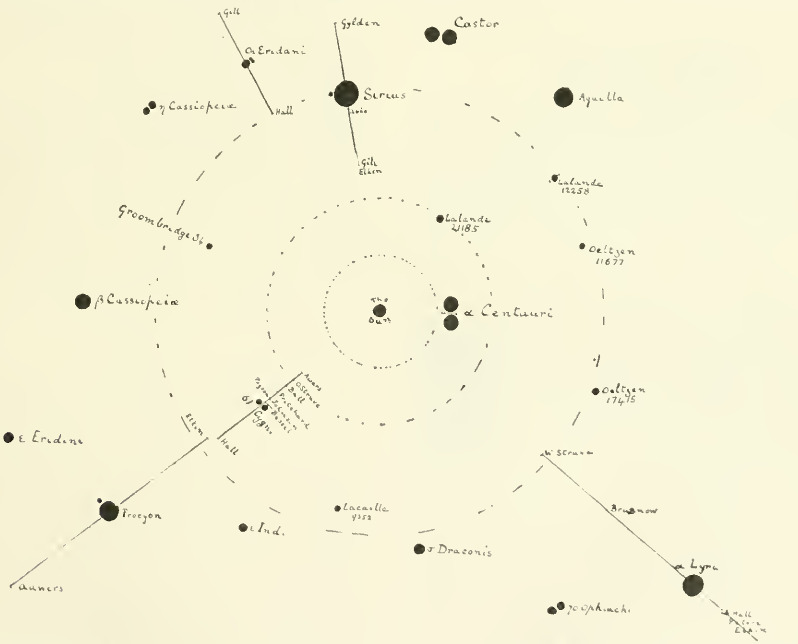


DIAGRAM SHOWING THE DISTANCES OF TWENTY STARS FOR WHICH LARGE PARALLAXES HAVE BEEN FOUND.

Aldebaran, with a parallax of 0″·116, would on the scale of the diagram have fallen outside the page. Mr. Monck's contention will not be affected by this, for I cannot count Aldebaran as a binary; there is no known physical connection between it and its minute companion 108″ off. The scale adopted is ten millimeters for the distance of a star with a parallax of one second of arc, or one millimeter for 20,626 radii of the earth's orbit.

Where there have been several determinations of the parallax of a star I have adopted a mean value, and have drawn a radial line indicating the range in distance corresponding to the various determinations.* All observations

a great range in the real magnitudes of stars, and probably many small stars having large parallaxes have not yet been detected.

As to the colours of double stars, Mr. Monck rejects my facts and appeals to authorities; but in this instance I venture to differ with Sir John Herschel, who has, I think, been a little too sweeping in the statement that "no green or blue star of a decided hue has hitherto been found unassociated with a companion brighter than itself." The stars referred to in my note are all described as decidedly

* The short line through the place of α Centauri corresponds to the determinations of Henderson in 1812, 0″·913; Maclear in 1851, 0″·919; Moesta at Santiago in 1861, 0″·880; and Gill and Elkin in 1882, 0″·750. The short line through Lalande 21,258, corresponds to the determination of Auwers in 1863, 0″·262, and Krüger in 1864, 0″·250. The line through α Lyra should extend outside the diagram. Dr. Elkin has recently determined its parallax to be only 0″·034 ± ·015; Peter's determination in 1846 was 0″·103: and Hall's in 1881, 0″·131.

blue by that careful observer, Dr. Gould, and they are all single stars. If Mr. Monck objects to my quoting instances from the southern hemisphere which he cannot verify himself, I will refer him to the striking case of Vega, which is a very blue star, and certainly has no companion brighter than itself. The small companion is also decidedly redder or lower in the spectrum than the principal star. I do not take such exception to Professor Young's statement, which, it should be noted, differs from Sir John Herschel's, for Professor Young confines his remark to double stars, and says that the smaller always lies higher in the spectrum. Vega is probably not an exception to this rule, as we do not know it to be double, and there is probably not any physical connection between it and its minute companion. But Sirius, which is an undoubted binary, is bluish-white, while its companion is reddish and cannot be described as higher in the spectrum than the principal star. The general law is, however, well worthy of remark, but we shall not lose by carefully noting the exceptions.

A. C. Ranyard

Notices of Books.

The Blowpipe in Chemistry, Mineralogy, and Geology. By Lieutenant-Colonel W. A. Ross, R.A. Second Edition. (London: Crosby Lockwood & Son. 1889.)—Colonel Ross is an enthusiastic blowpipe manipulator, and has done much service in popularising blowpipe analysis. The book contains descriptions of many varieties of blowpipe apparatus and appliances, and it is satisfactory to find that the author recommends simple and cheap as opposed to elaborate apparatus. As an advocate of hand, foot, and reservoir blowers as compared with the ordinary mouth blowpipe, he will be welcomed by many who, with out-blown cheeks, have lost patience, time, and breath in vainly endeavouring to fuse a refractory assay. The theory of the blowpipe flame is dwelt on; we are told that it is a solid cone of flame, and the oxidising and reducing flames of our youth are banished in favour of "oxyhydrogen" and "hydrocarbonous pyrocones" respectively, whilst our coloured blowpipe flames become "pyrochromes," a phraseology which contrasts curiously with the simplicity of the apparatus he recommends. That excellent and useful introduction of the author's—the aluminium plate support—is described, and its application to blowpipe assays explained. Many tables of rocks, minerals, ores, silicates, &c., showing their composition and their behaviour before the blowpipe, are interspersed through the book, and will be found useful. Whilst admiring the author's enthusiasm for the methods he has elaborated, we think that for purposes of instruction a terser style would have been better. The specific gravitometer, which he describes on p. 116, cannot be recommended, for one reason among others, the air cannot be satisfactorily expelled from the little box containing the gold dust, &c.

A Text-book of Elementary Metallurgy. By Arthur H. Hiorns. (Macmillan & Co. 1888.)—This little work has been arranged to meet the requirements of pupils preparing for the elementary stage of the Science and Art Department's examinations in metallurgy. In the first three chapters, which are more or less introductory, the technical terms in general use are defined and a description is given of the nature and properties of fuel. The usual methods of extracting the useful metals from their ores are explained, and sectional drawings of the various furnaces are given, as well as explanations of several iron and steel processes—Freibeg's process for silver, and the Welsh methods for copper. The book is written in a clear and simple manner, and can be recommended as a valuable addition to our elementary manuals.

Celestial Motions; a Handy Book of Astronomy. By W. T. Lynn, B.A., F.R.A.S. Sixth Edition. (London: E. Stanford.)—The fact that in five years Mr. Lynn's little treatise has gone through as many editions is a proof of its popularity with the scientific public. There are many decided improvements in the present edition, the work has been considerably enlarged, a chapter on the Calendar added, and the eight pages giving a list of the asteroids have been omitted, we think with advantage. Perhaps some reference to more recent investigations on the proper motion of the solar system than those of Airy and Dunkin might have been introduced, at least some notice should have been taken of Ludwig Struve's recent researches, based on the proper motions of more than 2,500 stars. The results of Peters's and Elkin's determinations of the parallax of Capella give a far smaller parallax than $0''\cdot3$, Elkin giving $0''\cdot11$ and Peters $0''\cdot07$, corresponding to thirty and seventy-one light years respectively, while Struve's value gives a distance of only eleven light years. But with these exceptions, Mr. Lynn's work appears to be very carefully and accurately brought up to date.

*Chambers's Encyclopædia.**—These volumes swell the evidence that Messrs. Chambers follow with unslackening zeal the traditions of their house in its honourable distinction of supplying high-class "information for the people" at a price which brings it within the means of the cottager. Our general survey—for only this is possible—of the articles in these instalments of a work the completion of which we await with eagerness justifies us in saying that the lofty standard of the first volume is maintained, and that where the articles may need revision, this will be only in virtue of that advance in knowledge which makes periodical recasting of all encyclopædic works necessary. Many of the articles, notably the biographical, will escape this, since their crisp presentment of facts and sound assessment of their several subjects render them final and complete. Mr. Davidson's general remarks under the head "Biography" are sound and discriminating, except where he gives even qualified commendation to that worthless piece of slop-work, Trollope's "Life of Thackeray;" and among the more admirable articles of the kind we may note Sir Geo. Grove's "Beethoven," Whyte's "Boccaccio," Andrew Lang's "Burns," with that undue prominence of the warts and wrinkles of the man which is also given in the "Letters to Dead Authors," Ornsby's "Cervantes," and Grant Allen's "Darwin." The article on "Buddhism" has been subjected to needful revision, the exposition of the doctrines of *karma* and *nirvana* being as clear as the obscurity of those theories permits. *Nirvana* is defined as including other ideas than those of annihilation, corresponding, as Rhys Davids has shown, to the Pauline "peace of God which passeth understanding." The biological articles, as might be expected from their writer's attainments, are masterpieces of lucidity and exactness, and it is surprising that under such limitations of space as the work imposes, Mr. Patrick Geddes should have contrived room for dainty and suggestive paragraphs such as the following, which adorns the article on "Botany." Speaking of the narrowing influences of mere fact-collecting, apart from care as to the significance of the things collected, he says:—

> The highest modern botany neither harvests plants with the herbalist, nor picks them to pieces with the child, but finds alike its rise and climax in watching the blossoms open and the bees come and go. The pedigree of the science is only on one side, from the

* Vol. II. Bea to Cata. Vol. III. Cata to Dion. (London and Edinburgh: W. & R. Chambers, 1888–1889).

herbals of Dioscorides and Brunfels to the system of Linnæus or Jussieu; the other and nobler line rises in Virgil's song of living nature, runs through the keen yet simple records of naturalists like those of Selborne and Walden, and culminates in the monumental volumes of the greater naturalist of Down. It is in the school, or rather garden, of Darwin, viewed both as the last of the old-world naturalists, and as the first of evolutionists and physiologists, that our modern "introduction to botany" must begin; studies in the herbarium of the systematist and the special laboratories of the physiologist, anatomist, and microscopist may follow thereafter as occasion requires. For the age of mere analysis, guided only by the love of incessant novelty, or even by that of unity amid details, is ending; the student may now approach the service in a new spirit, since he can interpret its literature as but the incipient record of that vast drama of the evolution of life at which it is his rare good fortune to be an awakening spectator.

In his summary of the "Darwinian theory," Mr. Geddes refers too briefly to the existing differences between the neo-Lamarckian school, to which Herbert Spencer is lending his support, and the school of which Professor Weismann is the chief representative, and which contends that the theory of the inheritance of acquired characters is not needed to explain the phenomena of the organic world—in other words, that changes acquired by the individual are never transmitted. We may, however, look for a full discussion of this when the article on "Evolution" is reached. Among the historical articles, we may call special attention to that on the "Celts" from the competent pen of Professor Rhys, who, with his true sense of historic continuity, deals with the persistence of pre-Celtic non-Aryan races and their influence in divers ways upon later settlers. The maps and woodcuts throughout these volumes are perfect in their clearness, and we hope that an undertaking into which the best workmanship possible is put will meet with the success which such efforts deserve and seldom fail to win.

Ed. Clodd.

Notes.

The June number of *Harper's Magazine* contains an interesting article by Professor George Darwin on the planet Saturn and his ring system.

At a recent meeting of the Meteorological Society, Mr. W. H. Dines gave an account of some experiments made to investigate the connection between the pressure and velocity of the wind. The pressure plates were placed at the end of the long arm of a whirling machine which was rotated by steam-power. Experiments were made with about twenty-five different kinds of pressure plates. The pressure upon a plane area of fairly compact form is about $1\frac{1}{2}$ lbs. per square foot at a velocity of 21 miles per hour; and as the pressure varies with the square of the velocity, a pressure of 1 lb. per square foot is caused by a wind of a little more than 17 miles per hour. The pressure upon the same area is increased by increasing the perimeter. The pressure upon a $\frac{1}{4}$-foot plate is proportionally less than that upon a plate either half or double its size. The pressure upon any surface is but slightly altered by a cone or rim projecting at the back—a cone seeming to cause a slight increase, but a rim having apparently no effect.

What causes the blue flame produced when salt is thrown into a coal fire? This is a question that is frequently asked, and has been answered many ways. It must be remembered that salt or sodium chloride consists of only two elements—sodium and chlorine. Sodium is known to be the great producer of yellow flame, and therefore it is quite reasonable to suppose that the chlorine has to do with the blue flame. Some recent experiments by Mr. N. Leonard support this view. He shows that the blue flame is also produced by some other metallic chlorides, but that it is not produced by other compounds of sodium. It is further demonstrated that certain compounds of chlorine containing carbon, such as chloroform, chloride of carbon, &c., also produce a blue flame when thrown in the fire. This has led to the conclusion that when salt is thrown on a coal fire, the chlorine forms a compound or compounds with the carbon in the coal, which by decomposing gives rise to the blue flame. This conclusion finds support in the fact that when salt is thrown on to a red-hot body containing no carbon, platinum for instance, the blue flame is not produced.

A VALUABLE LIBRARY.

In a street leading from Chancery Lane into Staple Inn is an institution which deserves to be better known. It is the free scientific library of the Patent Office. Mounting a high staircase you enter a hall with a series of bays on either side. In these, and in adjoining rooms, there are nearly 100,000 volumes arranged by subjects under the headings—Chemistry, Physics, Astronomy, Biology, Agriculture, Metallurgy, and so on. The visitor, after merely writing his name and address in a book at the door, is free to go anywhere, and take down any book he likes. The library is particularly rich in scientific periodicals, both English and foreign. The current numbers are laid out for inspection on two large tables, an advantage which the reader at the British Museum does not enjoy. The number of visitors to the institution shows rapid increase, especially since the hour of closing was made 10 p.m. instead of 4. The librarian reports that there were 80,000 readers last year.

THE FACE OF THE SKY FOR JUNE.

By Herbert Sadler, F.R.A.S.

Spots of any size are still of very rare occurrence on the sun's disc. During the month of June there will be no real night throughout the British Islands. On the morning of the 28th there will be an annular eclipse of the sun, which, however, will not be visible at Greenwich. The line of central eclipse enters Africa, near Walfisch Bay, on the west coast, and crosses the southern portion of the Continent till just south of the river Rovuma on the east coast; after that its track is entirely across the Indian Ocean. Minima of the Algol type variable δ Libræ (cf. "The Face of the Sky for April") occur on the 3rd at 10h. 7m. p.m., on the 10th at 9h. 41m. p.m., on the 15th at 9h. 15m. p.m., and on the 24th at 8h. 50m. p.m. Mercury sets nearly one hour and three-quarters after the sun on the 1st of the month, with an apparent diameter of $9\frac{1}{2}''$, and a northern declination of $21\frac{1}{4}°$, and will be fairly well placed for observation during the first week in June. After that he rapidly approaches the sun, coming into inferior conjunction at 11h. a.m. on the 19th. Subsequently he becomes a morning star, but rises in very bright twilight. He does not approach any naked-eye star very closely. Venus is a fine object in the morning sky, being at her greatest brilliancy on the 6th. On the 1st she rises at 2h. 28m. a.m., having an apparent diameter of 42″, and a northern declination of $11\frac{1}{2}°$. On the last day of the month she rises at 1h. 30m. a.m., 2h. 18m. before the sun, with a northern declination of 15° 20′, and an apparent diameter of 24″. On the morning of the 11th she will be very close to the 6th magnitude star 31 Arietis. Mars is absolutely invisible, being in conjunction with the sun on the morning of the 18th. Owing to his extreme southern declination, below 23° south throughout the month, Jupiter, though he comes into opposition

with the sun on the 24th, is not at all well situated for observation in these latitudes. He rises on the 1st at 9h. 51m. P.M., and on the 30th at 7h. 40m. P.M., his apparent diameter on the last day of the month being $46\frac{1}{2}''$. The following phenomena of the satellites occur between the time of the planet's being 8° above the horizon and midnight, G.M.T., on the days named. At 11h. 14m. P.M. on the 5th an ingress of the shadow of the first satellite, and at 11h. 41m. P.M. an ingress of the satellite itself. At 11h. 16m. P.M. on the 6th a reappearance from occultation of the same satellite. At 11h. 11m. P.M. on the 9th an egress of the second satellite. At 10h. 30m. 9s. P.M. on the 13th an eclipse (disappearance) of the first satellite. At 10h. 30m. P.M. on the 15th an egress of the shadow of the third satellite, and at 11h. 23m. P.M. an egress of the satellite itself. The satellite should be watched for change of brightness before egress. At 10h. 24m. P.M. on the 16th an ingress of the shadow of the second satellite, followed at 10h. 47m. P.M. by an ingress of the satellite itself. At 11h. 47m. P.M. on the 21st an egress of the shadow of the first satellite, and four minutes later an egress of the satellite itself. This transit should be carefully watched, as the satellite may be projected on its shadow. This will be a very good opportunity for observing whether the shadow is larger than it ought to be, as has been stated by some observers. (See Webb's "Celestial Objects.") On the 22nd, at 11h. 35m. P.M., an ingress of the shadow of the third satellite, and at 11h. 47m. P.M. an ingress of the satellite itself. This phenomenon should be observed for the reasons given above. On the 25th a reappearance from eclipse of the second satellite at 9h. 47m. 38s. P.M. On the 28th an ingress of the first satellite at 11h. 18m. P.M., and of the shadow at 11h. 24m. P.M. Here again the phenomenon of projection may occur. On the 25th there is a predicted eclipse of the fourth satellite, which is computed to disappear at 8h. 48m. and reappear at 9h. 55m.; but there will probably be no *real* eclipse, the satellite remaining visible as a speck of light in good telescopes. In any event it will just skirt the edge of the shadow, and any irregularities in its brightness due to clouds or inequalities of absorption in the atmosphere of Jupiter should be noted. At 10h. 59m. 35s. on the same evening there will be a reappearance from eclipse of the first satellite. Jupiter describes a short retrograde path in Sagittarius, but does not pass very near any naked-eye star. Saturn is still visible, but must be looked for very early in the evening to be seen to any advantage. On the 1st he sets at 11h. 12m. P.M., and on the 30th at 10h. 19m. P.M., his apparent diameter at that date being 16″. He describes a short path through Cancer into Leo. Uranus rises on the 1st at 2h. 56m. P.M., and on the 30th at 1h. 0m. P.M. He describes a very short retrograde path in Virgo, to the S.W. of θ Virginis. Neptune is invisible. There is no well-marked shower of shooting stars in June, owing probably to there being no real darkness during the whole month. The moon enters her first quarter at 8h. 2m. P.M. on the 6th, is full at 1h. 58m. P.M. on the 13th, enters her last quarter at 7h. 35m. A.M. on the 20th, and is new at 8h. 54m. A.M. on the 28th. There will only be one occultation visible—and that can hardly be said to be visible—at Greenwich during June. The 6th magnitude star B.A.C. 5758 will disappear at 3h. 44m. on the morning of the 13th, at an angle of 98° from the vertex, the moon being setting at the time; the reappearance will occur while the moon is below the horizon. At 11h. 26m. P.M. on the same evening there will be a near approach of the 6th magnitude star B.A.C. 6088, at an angle of 161° from the lunar vertex. At 2h. 34m. on the morning of the 20th there will be a near approach of the 5th magnitude star 30 Piscium, at an angle of 173° from the vertex.

Whist Column.

By W. MONTAGU GATTIE.

AMERICAN LEADS.

(*Continued from page* 155.)

In our last article we gave a brief explanation of the system of American leads; and, in pointing out the scientific uniformity of practice which it is aimed to establish, we, so to speak, stated the case of its supporters. It was originally our intention to proceed at once to consider the objections which have been urged against the system by its opponents, among whom are several distinguished players. But we have, in the meantime, received a letter, which we publish below, raising an interesting point in connection with the lead of the "penultimate," or lowest but one, from a five-card suit, which, as we have already seen, is a particular case of the first maxim of the American code; and, as we imagine that the illustrative hand furnished by our correspondent will, in the view of most of our readers, agreeably vary the monotony of theoretical discussion, we propose to defer reviewing the arguments of the opposing school till next month, when we shall also have something to say as to the extent to which the system is applicable to trumps.

We have already pointed out that circumstances may frequently arise in the course of a hand, under which it becomes necessary to modify or altogether to abandon any rule for leading. It will be seen that Mr. Hughes adduces a case which, in his opinion, justifies a departure from the penultimate lead; and, although we are not at present prepared to admit this contention, the question certainly affords fair ground for discussion.

To the Editor of KNOWLEDGE.

SIR,—I shall be glad of your decision as to the correct lead of trumps by a player holding five, when his partner has called.

The ordinary lead of the penultimate is—at any rate occasionally—open to the objection that the player's partner may be able to place the lower trump in his hand, and thereby infer that he has led from two trumps only.

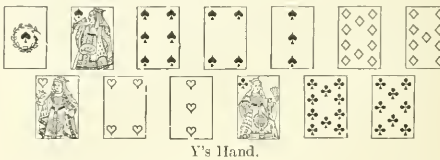
In the accompanying hand, which occurred in actual play, Z turned up the 2 of spades, and his lead of the 5 caused Y to infer that he had only the trump card remaining. Y therefore finessed ace, queen, although B's play had shown that he could take a certain ruff in clubs.

In my opinion, in answer to a call, the lead of the lowest trump, showing four or one, is more advantageous than the lead of the penultimate, and I should like to know whether this point has been discussed by the authorities on whist.—I am, sir, yours faithfully,

FRANK S. HUGHES.

Westminster: May 10, 1889.

HAND No. 4.

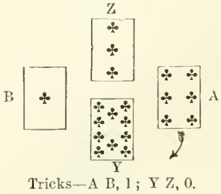


Y's Hand.

Score—A B, 0; Y Z, 1. Z turns up the 2 of Spades.

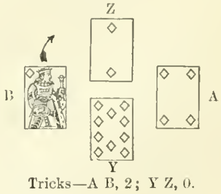
NOTE.—A and B are partners against Y and Z. A has the first lead; Z is the dealer. The card of the leader to each trick is indicated by an arrow.

Trick 1.



Tricks—A B, 1; Y Z, 0.

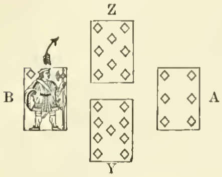
Trick 2.



Tricks—A B, 2; Y Z, 0.

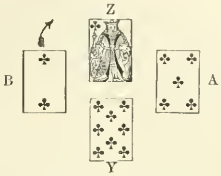
NOTE.—Y commences a "call" in both suits.

Trick 3.



Tricks—A B, 3; Y Z, 0.

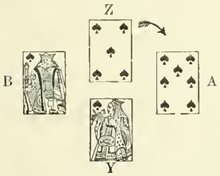
Trick 4.



Tricks—A B, 3; Y Z, 1.

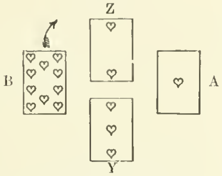
Note.—*Trick* 3.—B has shown four honours in diamonds, and therefore Z has no more diamonds. Y completes his call for trumps. *Trick* 4.—B has no more clubs; for A has shown five originally, and therefore has three remaining; and B cannot hold the other one (viz. the 4) or he would have returned it, instead of the 2. Therefore Z has the 4, and B will be able to make a trump on the third round of the suit.

Trick 5.



Tricks—A B, 4; Y Z, 1.

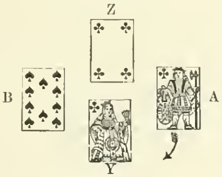
Trick 6.



Tricks—A B, 5; Y Z, 1.

Note.—*Trick* 5.—Z having turned up the 2, Y naturally infers that the 5 is his best, and therefore finesses

Trick 7.



Tricks—A B, 6; Y Z, 1.

Tricks 8 to 13 are won by YZ, who score

The Odd Trick and Two by Honours, and AB save the Game.

A's Hand.	B's Hand.	Y's Hand.	Z's Hand.
S.—7.	S.—Kg, 10.	S.—A, Q, 6, 4, 3.	S.—Kn, 9, 8, 5, 2.
D.—7, 6, 4.	D.—A, Kg, Q, Kn, 5, 3.	D.—10, 9.	D.—8, 2.
C.—Kn, 9, 7, 6, 5.	C.—A, 2.	C.—Q, 10, 8.	C.—Kg, 4, 3.
H.—A, 9, 8, 7.	H.—10, 6, 5	H.—Q, 4, 3.	H.—Kg, Kn, 2.

Remarks—Many players who adopt the lead of the penultimate from plain suits of five cards prefer to open with the lowest of five trumps. But, whether they are right or wrong in this, it can scarcely, we think, be maintained that the foregoing hand furnishes any substantial argument in support of the one course or in opposition to the other. Y, no doubt, was led to think that his partner had only the 2 of trumps remaining, and therefore finessed his queen; whereas, if he could have divined the actual state of affairs, he would have played his ace, and by continuing with a second round of trumps would have secured the game. But, if Z had led the 2, as Mr. Hughes proposes, would Y have been justified in playing his ace, on the chance that the lead was from four, notwithstanding the opposing strength in diamonds and his want of information as to hearts? After trick 4, it is clear to Y that Z has eight cards which are either hearts or trumps; and it may be urged that the chance of his holding seven hearts and one trump is less than the chance of his holding six hearts and two trumps. But in either case it would, in our opinion, be highly imprudent for Y to give up the command of trumps. Even as it is, with five trumps to the knave in Z's hand, it would not be difficult to find cases in which Y would miss the game by not finessing the queen; and, without positive information as to Z's strength, it would be quite contrary to principle not to finesse, seeing that the lead is in response to a call. It is worth noticing that some players with Z's hand would have also called for trumps; and, if Z had done so, Y would have been in no doubt as to the meaning of his lead at trick 5.

Elementary Explanation of the Play.

Trick 1.—A opens his longest suit, and leads the lowest but one from five; Y commences to call for trumps by playing the 10 as second player, although he holds the 8; B of course plays his ace; and Z, as he is not disposed to call for trumps, plays his smallest club.

Tricks 2 & 3.—B's is the correct lead from a suit headed by all four honours. Y calls for trumps by playing the 10 of diamonds before the 9. Z and A play their lowest cards to each trick: and, as B's lead shows that he holds ace and queen, it is clear that Y and Z have no more diamonds—*i.e.*, that all the remaining diamonds are with A and B.

Trick 4.—If B could now force Y, who has shown great strength in trumps, by continuing the diamond suit, it would be good play to do so; but, as Y and Z are both known to be void of diamonds, he would enable the weaker hand to trump and the stronger hand to discard some losing card. He therefore rightly prefers to return his partner's lead. Z of course puts on the king; and A, by playing the 5 after having led the 6, shows that he held five clubs originally. Y and Z, each of whom has one club remaining, are able to infer that B has no more, for he could only have one other, and, if he had had that, he would have returned it instead of the 2, in accordance with the rule to return the highest of two remaining of partner's suit.

Trick 5.—Z having obtained the lead, seizes the opportunity to get out the trumps, and, having five of them, leads the penultimate. Y very properly finesses against the king, which is as likely to be with A as with B.

Trick 6.—For the same reason as before, B avoids continuing the diamonds, and opens hearts in the hope that his partner may get in and give him a chance of ruffing clubs. He leads the 10 as being the best of a three-card suit. As Z holds king and knave himself, he knows the lead is not from king, knave, 10, and he is perhaps justified in assuming it to be (as it is) from weakness. It would, however, have been better play to put on the knave, under the circumstances, in case B should have led from ace, queen, 10.

Trick 7.—A knows from his partner's lead at Trick 4 that he has either queen and 4 of clubs or no more. In the latter case Y and Z must each have one of the suit; for, if Z had held the queen, he would have played it instead of the king at Trick 4; and, if Y had held the 4, he would have "called" with 8 and 4 instead of with 10 and 8. A therefore takes the best chance of saving the game by continuing the clubs.

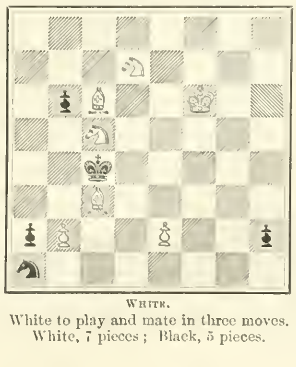
The remaining tricks obviously fall to Y and Z, as the student will see at once on dealing out the hands given above.

Chess Column.

[Our Chess column has been placed in the hands of Mr. R. F. Fenton during the absence of Mr. Gunsberg, who has gone to play at the International Chess Tournament in New York. Mr. Gunsberg will probably return early in June.—Editor.]

PROBLEM BY C. A. L. BULL.

Black.



White.

White to play and mate in three moves.
White, 7 pieces; Black, 5 pieces.

THE NEW YORK INTERNATIONAL CHESS CONGRESS.

The second round of the tournament is on the eve of completion, and before our time of going to press will be definitely decided. There have been many vicissitudes of fortune in the course of the protracted and exhausting struggle. For a long time Herr Max Weiss, the leading player of Vienna, held the lead, then M. Tschigorin, the Russian champion, just got in front and remained there, and at one stage Mr. Amos Burn, of Liverpool, well known for the strength and safety of his play, held the first place; neither must we forget that the English champion, Mr. J. H. Blackburne, has borne himself bravely in the fray, and always maintained a prominent position, together with S. Lipschutz, the young New York champion, who by excellent and consistent play has greatly increased his budding reputation.

At some distance from the above we find the well-known names of James Mason, Max Judd, J. W. Showalter, Eugene Delmar, and the veteran H. E. Bird, whose score would have been higher, had he not been obliged to forfeit a game by illness.

The position of Mr. Gunsberg on the score sheet will be a matter of congratulation to his friends, and particularly so when it is remembered that he was suffering for some days with a cold and sore throat that at one time threatened to assume a dangerous aspect. It will be convenient here to give the names of the several contestants and a summary of the games played, together with the games yet to be decided. A closer and more interesting finish we never remember. It will be seen that Max Weiss can still win the first prize by beating J. Mason, but if he is defeated he will tie with Mr. Gunsberg for the second prize, also that Messrs. Burn, Blackburne, and S. Lipschutz, can either win or tie in their scores.

SCORE INCLUSIVE OF SATURDAY, MAY 18, PLAY.

J. W. Baird	6 games	To play D. Baird and G. Gossip.
D. G. Baird	16 ,,	,, J. W. Baird.
H. E. Bird	17 ,,	Played all.
J. H. Blackburne ...	26 ,,	To play A. Burn.
C. F. Burille	14 ,,	,, S. Lipschutz.
Amos Burn	26 ,,	,, J. H. Blackburne.
E. Delmar	$17\frac{1}{2}$,,	,, M. Taubenhaus.
G. Gossip	13 ,,	,, J. W. Baird.
J. Gunsberg	$28\frac{1}{2}$,,	Played all.
J. H. Hanham ..	14 ,,	To play S. Lipschutz.
Max Judd	19 ,,	,, C. F. Burille.
S. Lipschutz	$24\frac{1}{2}$,,	,, J. Hanham and W. Pollock.
D. M. Martinez ...	$13\frac{1}{2}$,,	Played all.
J. Mason	$20\frac{1}{2}$,,	To play Taubenhaus and Tschigorin.
N. MacLeod	$5\frac{1}{2}$,,	Played all.
W. Pollock	$16\frac{1}{2}$,,	To play Max Judd.
J. W. Showalter ...	18 ,,	Played all.
M. Taubenhaus ...	$16\frac{1}{2}$,,	To play E. Delmar and J. Mason.
M. Tschigorin ...	29 ,,	Played all.
Max Weiss	$28\frac{1}{2}$,,	To play J. Mason.

The following game was played on the 10th instant in the second round, and resulted in a draw; the game in the first round between the same opponents was won by Mr. Gunsberg:

GIUOCO PIANISSIMO.

WHITE. J. Gunsberg.	BLACK. M. Tschigorin.	WHITE. J. Gunsberg.	BLACK. M. Tschigorin.
1. P to K4	P to K4	15. P to QKt4	B to Kt3 (c)
2. Kt to KB3	Kt to QB3	16. Kt to B4	P to K5
3. B to B4	B to B4	17. R to R3	Q to B4
4. P to Q3	Kt to B3	18. P × P	Q × P
5. Kt to B3	P to Q3	19. R to QB3	B to Q5
6. B to KKt5	B to K3	20. Kt to Q2	Q to K2 (d)
7. Kt to Q5	Kt to R4 (a)	21. R to KB3	Q to K7
8. B to Kt3	Kt × B	22. P to B3	B to Kt3
9. RP × Kt	B × Kt	23. P to QKt3	R to K2
10. P × B	P to R3	24. P to Kt3 (e)	KR to Ksq
11. B × Kt	Q × B	25. K to Kt2	R to K6
12. Castles (b)	Castles	26. Q × Q	R × Q
13. Kt to Q2	Q to Kt3	27. Kt to B4	R to R7
14. K to Rsq	QR to Ksq	28. Kt × B	RP × Kt

And the game in a few moves was abandoned as drawn.

NOTES.

(a) The best way apparently of neutralising Mr. Gunsberg's novel attack of Kt to Q5.

(b) Although White has the disadvantage of a doubled Pawn, he is quite compensated by remaining with a Knight against a Bishop.

(c) If he had taken the offered Pawn, he would of course have lost the QRP, and have been left with slightly the worst of the position.

(d) Taking the QP would have been followed by R to Q3 with damaging effect.

(e) But for this precautionary move, M. Tschigorin would soon get an advantage by a favourable exchange of Queens.

Since the above was in type the Tournament has come to a conclusion. Max Weiss and M. Tschigorin tie for the first and second prizes with 29 games each, J. Gunsberg wins the third prize with $28\frac{1}{2}$ games, and J. H. Blackburne the fourth with 27 games, the other three prizes fall to A. Burn with 26 games; S. Lipschutz, $25\frac{1}{2}$ games; and J. Mason, 21 games, in the order named.

The tie between Max Weiss and M. Tschigorin for first and second prizes will be played off under the following conditions embodied in Rule 4 of the Tournament:—"If two players tie for the first prize, they shall play a match for the first winner of two games, exclusive of draws; but after four draws the match shall terminate; and if the score be even, the prizes shall be divided; but if either player shall be a game ahead, he shall be declared the victor."

CITY OF LONDON CHESS CLUB.

In the match between Messrs. Block and Loman of seven games, Mr. Block has won 1, drawn 2, and lost 0. The great winter tournament is nearly over, Mr. Serraillier leading, having won 7 out of 8 games, and has only Mr. Loman to play. Mr. Kenning, however, may tie him, who has won 6 out of 8 games, and who has also to play Mr. Loman. Mr. A. C. Smith has finished all his games with a score of $6\frac{1}{2}$, and Mr. Loman has scored 4 with 2 yet to play. Mr. Rottjer, who had begun well, had to retire, owing to absence from London, and the same remark applies to Mr. Tarry. The spring handicaps have been commenced. In the first Messrs. Block, Morian, and Dr. Smith have won all their games played, and Mr. Herbert Jacobs 3 out of 4. In the second Mr. E. O. Jones, who has lately been raised to the first class, and Mr. Woon have each won their 4 games played. For the third the Rev. J. Watson has won 4 games out of 5, and Mr. Latham 3 out of 4.

NORTH LONDON CHESS CLUB.

The annual dinner of this important club was held at the London Tavern, Fenchurch Street, on the 9th inst., and was a great success, over seventy members and friends gathering round the table. Dr. Hunt, the president, was in the chair, and the treasurer, Mr. T. R. Howard, and Mr. C. E. Biaggini, the hon. secretary, occupied the vice-chairs. The visitors included Messrs. Clarke, Fenton, Gastineau, and Ridpath (City C.C.), Messrs. Carr, Peachey, and Schlesinger (Athenæum C.C.), Wallace (London Banks), Johnson (Blackfriars), E. Marks and Dr. Greenwood (Hornsey Rise), and Messrs. Biner and Kistruck (Shoreditch). It had been arranged that speeches should be conspicuous by their absence, so after the usual loyal toasts, Mr. Clarke, president of the City Club, proposed "Success to the North London, and the health of its President," which was responded to in a happy vein by Dr. Hunt.

ANSWERS TO CORRESPONDENTS.

ARTHUR GREATOREX.—It is an interesting end game, but the poor Black is in such a woeful minority of force that he must lose any way.

JAMES PAUL.—Your solution of M. Grosdemange's ingenious problem is correct.

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1. Taken at Balham on 6th June, 1889, by G. J. NINNES, looking S.E.

2. Taken at Balham on 6th June, 1889, by G. J. NINNES, looking S.E.

3. Taken at Sydenham on 6th June, 1889, by J. PORTER. Camera facing nearly East.

4. Taken at Ilford, Essex, on the 6th June, 1889, by

5. Taken at Balham on 6th June, by G. J. NINNES, looking S.E., 1889.

6. Taken at Ealing, on 6th June, 1889, by Dr. H. H. HOFFERT, D.Sc.

KNOWLEDGE

AN ILLUSTRATED

MAGAZINE OF SCIENCE

SIMPLY WORDED—EXACTLY DESCRIBED

LONDON: JULY 1, 1889.

CONTENTS.

HOW LONG DOES A FLASH OF LIGHTNING LAST?

By A. C. Ranyard.

THE recent thunderstorms came most opportunely, while the information given in the last number was fresh in the minds of the readers of Knowledge. A great storm swept across England on June 2, travelling northward from the coast of Wiltshire, past Liverpool and Edinburgh, and up into Scotland. According to observations collected by Mr. Marriott, the storm centre travelled at the rate of 50 miles an hour, and was attended by violent electrical disturbances as well as the fall in some places of extraordinarily large hailstones, some of which, according to trustworthy reports sent to the Meteorological Society, measured 7 inches in circumference and weighed 7 ounces. On the evening of Thursday, June 6, London was visited by a great storm, which also drifted northward. Mr. H. S. Wallis, a statistically-minded observer, counted 1,244 flashes in two hours as seen by him from Highgate, which gives an average of more than ten discharges per minute.

Most observers of this storm agree that the flashes were generally multiple flashes; they either describe a pulsation about the light of the lightning, or state that they saw distinct flashes, sometimes four or five in number, travelling along the same course with a perceptible interval of time between them. To my eye it seemed that the first flash was generally the brightest, and that sometimes a flash was succeeded by a glow which lasted an appreciable part of a second. I saw no ribbon flashes and no dark flashes. There were a very few observers who thought that they saw both; we will deal with their observations later on.

Amongst the photographs that were taken on the 6th were several of the so-called "dark flashes," and several photographs of ribbon flashes. There are also some photographs which show three or four flashes which evidently travelled along the same course. Photographs Nos. 1 and 2 are of this description. It might at first sight be thought that these were photographs of parallel flashes; but an examination of the original negative shows in each case a triple image of a railway signal-post, and that the three images of the signal-post are separated by about the same distance as the three flashes. The three images of the post correspond in intensity with the three lightning flashes, and the displacement was in the same direction on the plate: so that, if the three images of the post were made to coincide, the three images of the flash would also coincide turn for turn and knot for knot. We can, therefore, hardly doubt that the plate shifted between the three flashes, and that the lightning really passed, in each case, along the same path of least resistance. This is more probable, when we come to consider it, than that there should have been three parallel flashes in the air, which followed one another at an even distance through all the irregularities of the sinuous course which lightning pursues.

Indeed, from the facts already at our command, we might expect that the first flash would heat the air and slightly rarefy it, leaving a course of least resistance, along which subsequent discharges would flow as certainly as water follows the twists and turns of a pipe. When the original negatives are examined, the evidence as to the shift of the plates in the interval between the three flashes is overpowering. The evidence which we are able to present to our readers is not so strong as that derived from the original negatives, owing to the faintness of the photographic images of objects which are only illuminated by the light of a lightning flash. At the bottom right-hand corner of photograph No. 5 the summit of the signal-box referred to above is shown. The camera hardly moved during this flash, and it will be noticed that each post is surmounted by a pointed ornament. Photographs 1, 2, and 5 were all taken from the same spot. The signal-box is also shown at the bottom right-hand corner of photograph No. 2, but the overlapping images are ghostlike and hazy. On the original negative the three images of the pointed summits of the posts and the distance between them can be measured, and is found to correspond with the shift of the image of the lightning flash. In photograph No. 1 the image of the signal-box is lost, but three images of it are distinctly seen on the original negative, and the direction of the shift of the plate can be determined with certainty. There is a faint gauze, ribbon-like structure, which joins the middle flash with the left-hand flash. It is rather more dense in places where the flash has been moved obliquely across the photographic plate, but the nebulous veil is so faint that I fear no traces of it will be shown in the photographic copies published with this. However, a somewhat similar phenomenon will probably be recognisable on photograph No. 2, when examined with a lens. The right-hand flash is nebulous on its inner or left-hand side, and the left-hand flash is also nebulous on its inner side, proving that the one flash began and the other ended with a glow. There are two other small flashes which can be traced running parallel with the three larger flashes. The whole system of flashes appear to have passed behind a cloud in their upper portion. Where they appear above the cloud they are fainter, but the nebulous character of the outer flashes is more easily recognised than below.

In addition to these photographs in which we have photographic evidence that the plate was shifted during the exposure, a most interesting photograph was taken by Dr. H. H. Hoffert, who intentionally moved his camera *to and fro* while he pointed it in the direction in which flashes

might be expected. Photograph No. 6, Plate I., is made from a transparency kindly lent me by Dr. Hoffert; it will be seen that similar flashes are shown upon the plate at a considerable distance apart, joined by nebulous filaments. Dr. Hoffert says, in a letter to Mr. Marriott:—"With regard to the questions in your letter, I can give you the following general account of the way in which the photograph was taken. I was standing on a balcony, the rain having ceased. The storm had approached close and was all around us. At the point to which the camera was directed were occurring numerous brilliant discharges, at a distance of, I should think, half a mile to the east-north-east of my house, which is close to Ealing Broadway Railway Station and on the Green. The flashes seemed to my eye single. The camera was moved to and fro so as to make a complete period in about three-quarters of a second. I have thus estimated the period between the discharges as somewhere between one-fifth and one-tenth of a second. The period that the plate was exposed was between a quarter and half a minute. The aperture was $\frac{f}{8}$, and a rapid rectilinear lens was used."

Dr. Hoffert has kindly lent me two transparencies from this photograph which, when placed one over the other and slipped from side to side, show that the three great flashes in the lower part of the picture are exactly of the same shape. They each have a double brighter head which, when magnified, shows a series of knots or beads. The parts of the flashes which turn suddenly away from or towards the observer leave the brightest traces joining one flash with the other. The question arises, are these traces due to a glowing of the incandescent air in the path of the discharge, or to the light of a series of smaller discharges which continue to find their way down the path of discharge in the interval between the great flashes. If the glow is due to incandescent air we should expect to find it gradually and evenly subsiding as the air or gases cool, and this is certainly not the case.

On the right-hand side of the lower part of the middle flash a series of increases and decreases in the brightness of the nebulous field due to the glow can be traced, showing that the glow varies in brightness between the flashes. The glow, whatever it is due to, lights up again and cools several times in the interval between the great flashes.

This has produced a very curious effect in the case of the upper flash, of which there are three images at the top of the photograph. The left-hand image is seen to have a black line down it. In fact it has been described as a dark flash. When examined closely with a lens it is seen to be bordered by a series of tufts parallel to the traces joining the flashes. These tufts correspond exactly in position with brighter beads or knots on the other two bright images of the upper flash. And the dark channel is seen to be a division between two somewhat brighter fields produced by a glow which followed in the minutest details the curves as well as the knots and beading of the brighter flashes. The channel, in fact, corresponds to a period when the series of smaller discharges down the path of the flash ceased. I do not assert that all dark flashes are of this character, but here we evidently have one means by which a dark channel curving in the characteristic manner of lightning may be produced.

It is worthy of remark that the dark flash shown in photograph No. 4 in the June number was taken on a plate which evidently moved during the exposure, as is proved by the superposed images of the roofs at the bottom of the picture. Mr. E. S. Shepherd, by whom the photograph was taken, informs me that the camera was held by the hand on a window-ledge, and it is quite clear that the camera moved between the flashes which illuminated the roofs, though Mr. Shepherd was unconscious of any movement. A similar remark also applies to photograph No. 2 in the June number, also taken by Mr. Shepherd. It is one of the ribbon flashes along which runs a black flash or channel following the sinuosities of a parallel bright flash at the upper edge of the ribbon. In this case the camera seems to have been moved in a vertical direction. Mr. Shepherd informs me that the camera was held by the hand on the edge of the window-sill, and directed upwards, and he is unconscious of having flinched when the flash came; but nearly two years have now elapsed, and his attention was not then specially directed to the matter.

We rejected this theory of the origin of ribbon-flash photographs in the article in the June number, because we then believed lightning flashes to be as instantaneous as the electric discharges which can be experimented upon in the laboratory, and because it seemed that the striæ across the ribbon flash in photograph No. 1 in the June number were not quite parallel on different parts of the plate; but I have since had an opportunity of examining the negative of this flash, which was taken on a large plate, and I have satisfied myself that the want of parallelism is due to the optical distortion of the lens with which the photograph was taken.

As far as I have yet learnt, the photographs of broad ribbon flashes have all been taken with instruments held in the hand, or held against a fixed support, but not screwed to it. If we account for all the photographs of ribbon flashes by an assumed motion of the plate during the exposure, we are still confronted by the observations of those naked-eye observers who believe that they have seen ribbon flashes in the heavens. The observation must be a very difficult one to feel any certainty about. It is only since ribbon flashes have been photographed that a few observers think that they have seen ribbon flashes in the heavens, and we have to set against them a much greater number of observers who have watched for ribbon flashes during the same storms and seen none. It is very easy to deceive ourselves with respect to any observation which lies near to the limits of our senses—and there is another possible explanation. If the most sensitive part of the eye were not turned in the direction of the first flash, the eye would involuntarily turn so as to place the most sensitive part of the retina in the right direction; and if the second flash occurred before the image of the first flash had faded from the retina, it is very conceivable that an observer would suppose himself to see two parallel flashes. It is known that the sensitiveness of the retina of different persons for such after-images differs greatly, and hence such a phenomenon, though noticed by one, might not be seen by another. Similarly, the appearance of the dark flash would be accounted for by a coloured persistent image of a previous lightning flash remaining on a sensitive retina. We are all familiar with such after-images after staring at the sun; a sensitive eye may see them after looking at a lightning flash.

In addition to the broad ribbons referred to above, a narrow ribbonlike appearance may be caused at the edge of the plate by lenses which give very sharp images of ordinary objects; for lightning flashes are so bright that optical imperfections show themselves which would not affect the sensitive film around the image of an object of ordinary brightness. With the short focussed cameras in use, the pencils of light fall very obliquely at the edge of the plate, and the oblique sections of such pencils just beyond the focus frequently consist of a bright point with a nebulous tail, the shape of which varies greatly with the optical system used. Photograph No. 10 is an illustration of such optical distortion at the edge of the plate.

7 & 8. Taken at Dubuque, Ia, U S. Ameriea, on the 17th of July 1887, by G. E. Davis.

9. Flash of lightning taken 31st July 1887, by A W. Nicholls, developed on Photograph of the Castle Mound, Fotheringhay, taken the next day.

10 Taken at Bolsize Park, London, on 17th August, 1887, by W. Shuter. Enlarged two-and-a-half diameters.

Colonel Tupman has also sent me a negative of a lightning flash, showing a very distinct ribbon form at the edge of the plate, evidently due to considerable optical distortion. He has also sent me a beautifully sharp photograph of a landscape taken with the same lens set at the same focus. The examination of photographs of lightning flashes taken with instruments which have been well focussed affords an excellent means of studying the optical imperfections of the lenses employed.

But though the lightning flashes are bright enough to bring out the optical defects of the instruments, they are not bright enough (certainly as a general rule) to give rise to photographic reversal, such as would cause the line of the bright flash to appear dark upon the plate. I come to this conclusion for the following reasons. The photographic images of sparks taken in the laboratory do not show photographic reversal. The giant flashes in Nature's laboratory, of course, might do so, but none of the photographs of dark flashes I have seen show bright borders, such as one would expect to find, corresponding to the nebulous borders due to the optical imperfections of the instrument. Take, for example, photograph No. 8. If the light of the great branching flash were intense enough to cause photographic reversal at its centre, the hazy border at its edges would remain white. I have seen a paper print of one such dark flash with bright branches, which may possibly be due to photographic reversal; but one ought to have an opportunity of examining the original negative before coming to a definite conclusion. The mystery of the black flash cannot yet be regarded as completely solved. The further one proceeds in such an inquiry the more curious phenomena crop up, which need investigation. The bright beaded heads or knots in the air with which many flashes appear to commence are well worthy of study. Examples of such bright heads to flashes are shown in photographs Nos. 4 and 7, as well as in Dr. Hoffert's photograph.

Especial attention ought, during a future storm, to be given to measuring the time occupied by the phenomenon of a recurrent flash with a revolving cylinder or band of sensitive paper driven by clockwork, at a known rate, within the camera. In Dr. Hoffert's interesting photograph the great flashes appear to have the form of a narrow ribbon. One edge of the ribbon is quite sharp, and in the image of the great flash in the centre of the plate there is on Dr. Hoffert's photographic transparency (but not on the photographic copy published with this) a narrow line between the sharp edge and the remainder of the ribbon, as if the flash had consisted of an almost instantaneous discharge, and after a minute interval of time another discharge of considerable brightness, which lasted for a very short period, but still sufficiently long to show evidence of the motion of the plate. The dark interval between the flash and the ribbon shows that there was an interval of darkness, and that the ribbon cannot be due to incandescent air left in the wake of the flash.

A recurrent flash seems to be a very complicated succession of discharges lasting for an appreciable part of a second. The giant discharges which take place during a storm between irregularly-shaped and badly conducting masses probably differ materially in character from the flashes produced in a laboratory between good conductors. In the laboratory the whole flow takes place at once. In nature there seems to be a flow or rush succeeded by a dribble, which ceases or nearly ceases, and commences again and again, flow after flow rushing down the same path until the potential along the line of discharge is equalised. There seems to be no evidence of a back rush or alternate backward and forward flash, as has been suggested. On Dr. Hoffert's photograph, and in our plates Nos. 1 and 2, and in the many ribbon flashes, all the parallel threads or flashes thin out in the same direction. If there were alternate flashes we should expect to find one thick at one end, and the next thick at the other. In Dr. Hoffert's photograph the left-hand flash of the lower series (which is the only branched flash on the plate) seems to have been the first in point of time, and the right-hand flash of the upper series of flashes seems to end with the black channel as an expiring effort.

The extreme rapidity of lightning has long been used as a synonym for that which is instantaneous. In our proverbial philosophy, "Quick as lightning" and "Like a flash of lightning" have been used to denote the explosive suddenness of changes which occupy less time than the twinkling of an eye. But we need measures of these things for a more exact philosophy.

NOTE BY MR. W. MARRIOTT.

I fully concur with Mr. Ranyard as to the photographs of ribbon flashes being due to a movement of the plate during its exposure to one of the recurrent flashes described in the second paragraph. As far as I am aware, no photograph of a ribbon flash has been obtained with a camera on a fixed support. The motion of the camera in photographs 1 and 2 is clearly proved by the superposed images of the signal-box, which seem to correspond in position and intensity with the different images of the lightning flash. An appearance of a narrow ribbon may also be produced by optical causes near the edge of the plate, where the pencil of light from the lens falls obliquely and the sensitive film is either beyond or within the focus; the section of the pencil of light is then not circular, but usually consists of a bright point with a nebulous tail, causing a hazy edge to the bright image of the flash. In these latter cases the ribbon character is not continued all across the plate, but the breadth of the flash and its hazy edging vary with the distance from the centre of the plate.

I also concur as to the multiple character of many of the flashes during the storm on June 6, and it seemed to me that the first flash was the brightest; this was succeeded by less brilliant flashes along the same course. In one instance I saw two flashes which appeared to me to be parallel, and separated by a dark interval. In this case the second flash was certainly the fainter. I am not sure that the apparent duplicity of the flash was not due to a motion of the eye, which would involuntarily be directed so that the second flash would fall on the most sensitive part of the retina, if in the first instance it had not done so.

TIGER-BEETLES.—II.

By E. A. Butler.

TIGER-BEETLES not only run with great agility, but readily take flight as well, and hence are rather difficult to capture; and as their eyes are prominent and can take in a wide horizon at one view they need to be very warily "stalked." The organs of flight are a pair of dark-coloured membranous wings (fig. 4), which, under ordinary circumstances, are packed away out of sight, beneath their green, horny covers. Being larger than their covers, they have to be folded up before they can be packed away; this is done twice transversely, the tip being bent round towards the base, and a second bend in the same direction then made higher up the wing, and then the two wings, as they lie along the back, partially overlap one another. Keeping these arrangements

in mind, and remembering that the insects are able instantaneously to start off through the air at apparently full speed, and with equal suddenness to arrest their course and alight on the ground, we see at once further illustrations of the extreme rapidity of movement of which they are capable. In order to commence flight, the wing-covers, or elytra, have to be raised and spread outwards, so as to liberate the wings, which in their turn have to be unfolded and expanded horizontally; but all these movements are performed so expeditiously that the eye cannot follow them, and the insect seems in an instant to rush into the full force of its headlong career. The elytra are kept extended during flight, but do not themselves take part in the operation, being simply raised to allow free play to the wings. The flight is not of long duration, but the beetle simply dashes away a short distance at break-neck speed, and then suddenly settles, all trace of the wings disappearing the instant it alights, if not the moment before.

Fig. 4.—Wing of Tiger-Beetle. The dotted lines indicate where the wing is folded.

There is a species called *Cicindela sylvatica*, larger than our common green tiger-bettle, of a deep violet-brown colour, and found pretty commonly on the heaths of Surrey, which takes somewhat longer flights than its green ally, though its movements are conducted in a similar manner. But on the other hand, our smallest species, *C. germanica*, found in *wet* places, especially at Blackgang, in the Isle of Wight, scarcely uses its wings at all, but employs itself in *running* about over the marshy ground it frequents. Some of the exotic *Cicindelidæ* are destitute of wings altogether, and are perforce confined to the ground. A few species in the tropics run about over the leaves of trees, apparently in pursuit of other arboreal insects. Some, again, are found on sandy seashores; belonging to this group is our own *C. hybrida*, a brownish insect, with a curved creamy band stretching partly across the elytra, and a few other creamy markings. It is the same size as *C. campestris*, viz., about half an inch long, and almost exactly the same shape. These maritime species are often protectively coloured. Bates mentions two tiger-beetles which he found on a sandy shore in America, one of which was of a pallid hue like the sand it ran upon, and could therefore readily escape detection. The other, however, was of a brilliant copper colour, and therefore exceedingly conspicuous; nevertheless it was as well protected as its obscure neighbour, for it was possessed of a strong and offensive smell, a mixture of that of putrid flesh and musk. The sand-coloured one, on the other hand, being sufficiently protected by its colour, was perfectly devoid of any such odour.

It is now time to say a word about the earlier stages of these insects. We will take for this purpose our common green species, *C. campestris*. The larvæ (fig. 5) are odd-looking creatures, and may easily be found in the situations frequented by the perfect insects. A number of circular holes will be observed in the ground, which are the entrances of their cylindrical burrows; from these they may, with a little care, be dug out. If a trowel be inserted in the ground some six or eight inches from one of these openings, into which a straw or stem of grass has been previously passed, so as to render the direction of the burrow evident even if the earth should fall in upon it, the burrow may be traced to its end, descending vertically to a depth of from six inches to a foot, according to the nature of the soil and the age of the larva.

Fig. 5.—Larva of Tiger-Beetle.

Except in the jaws there is little resemblance between the larva and the adult insect. It is a whitish fleshy grub, with a broad, and what at first sight seems to be a decidedly *black* head. A lens, however, brings out the fact that what appears to be pure black is relieved by a dash of metallic green. In this extremely inconspicuous and almost invisible green we have the sole indication of the brilliant coloration destined to appear in the perfect insect; no doubt, however, the total absence of colour on the hinder parts is largely connected with the subterranean habits of the larva. The head is most strangely shaped; it is very hard, and its upper surface is rough and concave, the latter a most exceptional circumstance. Beneath it is the exact reverse of this, being highly polished and extremely convex, and of a mahogany brown colour (fig. 6). The segment immediately behind the head is equally broad, semicircular in shape, and covered above with a hard, horny skin, which is usually much encrusted with earth. The next two segments are similarly protected above, but are considerably smaller. All the rest are quite soft. The three shielded segments carry each a pair of legs, and are thus seen to correspond to the thorax of the adult. For a larva of this kind, the legs are much longer and thinner than might have been expected, a prophetic indication of the peculiarity that will characterise the limbs of the perfect beetle, and their apparent length is again increased by the placing of their point of attachment to the body almost at its sides instead of in the middle line, as is usually the case. The eighth segment after the head is surmounted by a large hump, which carries a pair of long hooks (fig. 7), which are movable, and can be erected and depressed at pleasure.

Fig. 6.—Head and First Thoracic Segment of Tiger-Beetle.

Fig. 7.—Dorsal Hooks of Larva of Tiger-Beetle.

This brief sketch of the creature's form will have prepared us to understand how it makes its burrow and catches its prey. The eggs are laid by the parent insect where the larva will have no difficulty in selecting a spot for sinking its shaft. It begins excavating by nipping off fragments of the soil with its jaws, which, instead of projecting straight forwards or sloping down from the head as is almost universally the case, slant upwards, rising thus above the level of the margins of the concave head-surface. As the burrow deepens, a difficulty arises as to the disposal of the particles of soil removed. Then it is that the object of the peculiar structure of the head becomes apparent. While the animal is working with its head down in its burrow and its body projecting above, the fragments of sand and earth, as removed by the upward sloping jaws, fall on to the concave surface of the head, which is thrown back till it is at right angles to the body, to receive them as in a shovel or saucer. A load having been thus obtained, the grub backs out of its hole by means of its legs, carrying its little saucerful of earth with it. These operations are repeated till the burrow is of sufficient depth, the animal always working with its head downwards. When, however, the shaft is completed, the grub reverses its position and drops into the hole with its head upwards. It can then work its way up and down this vertical shaft, much in the same way as the chimney-sweepers' boys used to climb chimneys, using its legs and the hooks on the eighth segment to give it purchase against the sides of the burrow.

In order to catch its prey it posts itself at the top of the burrow, with its body in the shaft and its head and the semi-

circular segment behind just blocking up the entrance, and maintains itself in this vertical position by means of its legs and dorsal hooks. Here it remains in ambush, with jaws wide open, till some unwary insect comes within reach, when the head is violently jerked backwards and the prey seized by those relentless jaws with a tenacity of grip that renders futile all efforts at escape. The grub then hurries to the bottom of its den, dragging its prey with it; here it crouches, bending its body somewhat in the form of a Z, and devours its victim at leisure. As might be expected of an insect that trusts so much to chance for a meal, it is not at all fastidious, but will eat any living thing that comes in its way, not disdaining even its own species.

The exact length of time spent by the insect in this condition is difficult to estimate, and probably depends to some extent upon the abundance or scarcity of food. Larvæ, as well as perfect insects, may be found during a great part of the year, and the exact periods of its changes cannot be stated with any certainty. Like all other beetles, it becomes, when full fed, a helpless pupa or chrysalis; not a limbless thing such as that of a butterfly or moth, but more lifelike, inasmuch as the legs and other organs are apparent on the outside, though of course covered with a skin which renders them quite unusable. In this helpless condition it lies at the bottom of its burrow till ready to make its final moult, taking no food, but quietly effecting beneath its skin all those marvellous changes that are necessary to transform it from an unadorned, fleshy, crawling grub, into a hard-cased, brilliantly-coloured, flying, and predaceous beetle. Before becoming a chrysalis, it is said to guard against intrusion by closing the entrance of its burrow. When the bright spring weather comes round, it issues from its subterranean chamber in its perfect form, a sparkling, agile hunter, destined never to return to its hermit cell, but to spend the rest of its days basking in the sunshine, making war upon the other denizens of its ancestral bank, and laying the foundations of future generations.

PHOSPHATES AS FERTILISERS.

By D. A. Louis, F.I.C., F.C.S.

Phosphorus in the free state is a highly inflammable and remarkably poisonous substance; it is familiar to every one as a material used in the manufacture of matches, and as a constituent of a paste for poisoning mice. When phosphorus is ignited in the air it burns with considerable briskness, evolving great heat and clouds of smoke. The product of the burning is a white substance, which dissolves readily in water, and has an intensely sour taste as well as other properties characteristic of a strong acid; it is, in fact, the substance known as phosphoric acid. By mixing this acid with an alkali or base, such as soda, potash, or lime, all the acid properties and the sour taste disappear, because the phosphoric acid and the base become intimately and firmly attached to one another, forming a compound having neutral properties and known as a "phosphate." In this form not only is the phosphorus non-poisonous, but it even becomes an essential constituent of living matter, and neither animals nor plants can thrive unless they receive a proper supply of it. Phosphates must therefore be included in our food. We either directly (as from bread and vegetables) or indirectly (through meat or the flesh of animals feeding on vegetation) obtain our supply of phosphates from the vegetable kingdom; therefore, in order to discover the source of our own phosphate supply, we must learn which plants contain phosphates, where they get them from, and how they get them. The existence of phosphates in plants is easily demonstrated, for when a plant is burnt the phosphates remain in the ash, and numerous careful analyses of plant ashes have enabled chemists to ascertain the average amount present in different plants. The numbers representing the average quantity of phosphoric acid present in some of our most useful crop plants are arranged in the second column of the following table, and in the third column are given the numbers representing the average quantity of ash which remains when 100 lbs. of the various plants are burnt; whilst the data in the fourth column show how much of this ash consists of phosphoric acid. In the first column are placed the names of the materials to which the various numbers relate. It is interesting to notice how each plant collects a different amount of phosphoric acid, and disposes of most of it in such a way as to be of use to succeeding generations of the plant. Thus the largest proportions of phosphoric acid are accumulated in the seeds; or when the roots store up nourishment, as in the case of turnips and potatoes, the preponderating quantity of phosphoric acid is found in the roots, which if left in the ground would serve as a store of food for the future development of the plants.

	100 lbs. of the substance named in the first column contains the following quantities of				100 lbs. of Ash from the substance named in the first column contains the following quantities of Phosphoric Acid.	
	Phosphoric Acid.		Ash.			
	lbs.	oz.	lbs.	oz.	lbs.	oz.
Wheat, grain		12¾	1	11	46	3¼
„ straw		3½	4	9¾	5	6½
Barley, grain		12¼	2	3½	32	13
„ straw		3	4	2	4	5
Pea, grain		13¾	2	5½	36	5
„ straw		5½	4	6½	7	13
Field beans, seed	1	3	3	1	39	3
„ straw		5¼	4	6¼	7	13
Potatoes, tubers		2½		15	19	1½
„ haulm		2½	1	15½	5	8
White turnips, root		1½		11¼	17	6½
„ leaves		1½	1	3	8	14½
Mangels, root		1		12	9	9¾
„ leaves		1¼	1	6½	5	1¾
Meadow hay		6½	5	2½	6	3¼

All these plants, and in fact all plants, obtain their phosphoric acid from the soil, and insignificant as the amounts appear in the above table, nevertheless, when the total weight of crop is taken into consideration, the real magnitude of these quantities soon becomes manifest. It is found, for instance, that a crop of wheat yielding 30 bushels of grain per acre will take from the soil a quantity of phosphoric acid which would be represented by a dressing of over 140 lbs. per acre of a rich superphosphate containing 25 lbs. of soluble phosphate in every 100 lbs. In a similar manner a crop of barley yielding 40 bushels per acre will remove phosphoric acid equivalent to a dressing of nearly 140 lbs. per acre of this rich superphosphate, whilst the phosphoric acid removed by a crop of 6 tons of potatoes, or 17 tons of turnips, or 22 tons of mangels per acre, would be represented respectively by dressings of 162, of more than 220, and above 350 lbs. per acre of the superphosphate.

And the farmer has to produce at the present time such crops as these, or even larger ones, in order to make things pay. It must be remembered, too, that most of the phosphoric acid removed from the soil in these crops is irretrievably lost to it; for except when crops are used for

feeding cattle, horses, &c., only those portions poorest in phosphates are utilised on the farm for litter, &c., and subsequently find their way back to the land in the form of farmyard manure; whereas the richest portions of the crops, such as the seeds of most cereals, and edible peas and beans, the tubers of potatoes, and a good share of the roots and hay in the form of meat, are sold off the farm for human consumption, and then the phosphates, along with many other valuable constituents, find their way in the majority of cases to the nearest stream or river, and ultimately to the sea. The quantity of valuable material lost in this way is enormous.

If the supply of phosphates available for the plant falls short, then the plant thrives badly, and yields light crops and inferior produce. As an example of this, some data are arranged in the next table, embodying results obtained by Sir John Lawes and Professor Gilbert at Rothamsted. In the first column are given the names of the crops; in the second the average weights of the yield of these crops when grown on a soil containing only a small quantity of phosphates, but receiving an abundant supply of nitrogenous manure; in the third column are given the average weights of the yield of the same crops, on the same soil, with the same quantity of nitrogenous manure, and, in addition, a supply of phosphates; in the fourth column are shown the increases in crop yield obtained by supplying the requisite phosphate:—

Crops.	Yield per acre, when grown on the same soil, with ample supply of Nitrogen.		Increase in yield per acre obtained by the use of the superphosphate.
	With insufficient supply of Phosphates.	With plenty of Phosphates as superphosphate.	
Wheat . .	3,274 lbs.	4,204 lbs.	930 lbs.
Barley . .	3,374 ,,	5,006 ,,	1,632 ,,
Hay . .	3,220 ,,	4,564 ,,	1,344 ,,
Turnips . .	1,792 ,,	10,194 ,,	8,402 ,,
Potatoes . .	5,334 ,,	17,192 ,,	11,858 ,,
Mangels . .	19,936 ,,	25,088 ,,	5,152 ,,
Sugar-beet .	29,008 ,,	35,728 ,,	6,720 ,,

The figures speak for themselves as to the amount of the harvests. The quality of the produce is also improved, for example, in the case of potatoes; the percentage of good tubers is 91 with and 85 without the superphosphate. This table illustrates another point—a point to which attention was drawn in the concluding lines of the article on "Nitrates" in the March number of Knowledge, p. 102, and which refers to the imperfect utilisation of nitrogenous manures in the absence of other plant-foods in the soil; it must, however, be borne in mind that the above increase in crops is obtained by the addition of only two important constituents of plant-food, viz., phosphoric acid and calcium. Nevertheless, the quantity of nitrogenous manure rendered active by them is very striking.

Having thus far shown the necessity and the advantage of supplying plants with phosphates, attention will now be turned to the sources of the phosphates for the supply of plants. And here we observe one of those interesting and wonderful compensating influences which are at work everywhere in nature; for the supply of phosphates for plants is largely, almost entirely, derived from animals past and present, so that in this way animals return to the soil material in a form useless to themselves but upon which plants thrive vigorously and reconvert into a form which is then available for the requirements of animal life.

The first and, as regards origin, the simplest supply of phosphates for plants is found in farmyard manure, stable-litter, sewage, and such like matters which are mainly the rejected products of living animals. The animal consumes in its food amounts of phosphoric acid considerably in excess of its requirements, and consequently when passing through the body this excess is not digested, and is ultimately rejected by the animal along with other indigestible matter and waste products produced in the animal organism. These supplies of phosphates are therefore much mixed up with all sorts of other material, and in fact contain only a small proportion of phosphates. The next source of phosphates is the dead animal, and, as in the case of plants, the phosphates are found in the ash. Now flesh contains (speaking very generally, for all kinds of flesh differ to a certain extent in the amount of ash) about 4 to 6 per cent. of ash; bone, also speaking generally, contains 60 to 70 per cent. of ash; it will therefore be seen that the latter parts of the dead animal would naturally be looked to to supply most phosphates.

Bone consists of both organic matter and inorganic matter or ash constituents. If a bone is allowed to soak in dilute hydrochloric (muriatic) acid, all the ash constituents are dissolved out, and the bone, while retaining its original shape, becomes translucent and soft, and in fact is then nothing more than a lump of jelly mixed with some fat. If, on the other hand, a bone is boiled in water, it loses all the fat present in it and some gelatin (jelly). This fat is used for making candles; the gelatin for size. By steaming the bones in closed vessels a further quantity of gelatin is extracted and furnishes a kind of glue. By subjecting bone to a still greater heat in a retort over a fire, most of the organic constituents distil off, forming what is known as Dippel's oil, and a residue of carbonised organic matter, "animal charcoal," is left in the retort. But by burning animal charcoal or fresh bones in the air, all the organic matter is consumed and the ash only is left behind. When bones in these different stages are examined chemically the amount of phosphates they contain nearly approaches the following quantities:—

100 lbs. of	Contain lbs. of Phosphates
Fresh bones	50
Boiled bones	50 to 60
Steamed bones	60 to 70
Animal charcoal . . .	70 to 80
Bone ash	80 to 85

However, as might be expected, bones in all these states show great variation in the quantities of phosphates they contain, but the value of bones as a phosphatic manure follows the order above given, bone ash being the best.

In nature, wherever animal matters accumulate they suffer changes in an order closely resembling that described above in the artificial treatment of bone; first the most delicate and volatile parts suffer decay, then the tougher portions, until the bones alone remain; then the bones decay in a similar manner until only the ash constituents remain.

In past ages such deposits have accumulated, and we find the bones buried in the earth; they have retained their shape in many cases, but almost always all the organic matter has gone, its place being taken by mineral matter. The deposits are dug up and the material comes into the market as fossil bones; large quantities come from South Carolina in the United States, also from Cambridgeshire, Buckinghamshire, and Suffolk, in England, from the North of France, and elsewhere. Sometimes the fossils have almost entirely disappeared, and the remains have become intimately mixed with the rock; such is often the case in the Belgian deposits near Mons, in some of the deposits in the North of France, and in other deposits in the neighbourhood of Bordeaux, in Nassau in Germany, and in the west of

Spain. In fact, in the three latter localities, extensive masses of mineralised phosphate known as "phosphorite" occur.

Sometimes phosphates are found in a highly mineralised condition in well-defined crystals, which have evidently been deposited from solution in the rocks where they are found. Such phosphates are found in old rocks in Canada and Norway, also in Spain, and are known as apatites; they consist of calcium fluoride and phosphate, and sometimes, as is the case with Norwegian apatite, of the chloride as well. The crystals sometimes are of considerable size: some very big ones from Canada were exhibited in the Indian and Colonial Exhibition, and looked like hexagonal pillars artificially shaped.

Other sources of phosphate for the farmer are the guano deposits. They mainly originate from the excretory deposits of sea birds; when fresh or in protected places the deposits contain much organic matter, and consequently nitrogen as well as phosphates, but in old deposits or in places exposed to severe atmospheric influences, heavy rains, heat, &c., the organic matter has disappeared and only inorganic matter remains, which in course of time becomes washed into and mixed up with the rock. Nitrogenous guanos are found on the islands near to and on the coast of Peru, in Patagonia, and the Falkland Islands in South America, and on the islands of Ichaboe and Ascension in Africa. Guanos containing phosphates but no nitrogen are found on many of the West Indian islands, in Mexico, on some of the islands in the South Pacific Ocean; also on the Kuria-Muria islands in the Arabian Sea; in New Guinea, Australia, &c., &c. In some localities the guano is found deposited along with other animal remains, and bones, teeth, and shells are found mixed up with it. Curaçao and Barbadoes guanos are of this type.

Coprolites consist of nodular, spherical, and irregular lumps of phosphate, which are dug out of the earth in Cambridgeshire, Buckinghamshire, Bedfordshire, and Suffolk, in England. They are also found in the north of France, in Russia, and in Austria. They are supposed to be the fossilised excreta of huge extinct lizard-like animals, but in the majority of cases there is little or no evidence to support this supposition.

All the natural phosphates that have been here considered are insoluble, or practically so, in water; they cannot, therefore, in the raw state be easily distributed in the soil so as to be accessible and useful to the plants. Fortunately, however, simple treatment with sulphuric acid (oil of vitriol) converts them into a soluble form of phosphate and gypsum; such mixtures contain all the other fixed constituents of the original raw phosphate, and are known as superphosphates. The phosphate in superphosphates is mostly soluble, and, when applied to land, is washed into the soil by rain, and becomes well distributed throughout so as to be readily accessible to the plant roots; in contact with various soil constituents it, however, soon again assumes an insoluble form, and is, therefore, not washed away like nitrates. Before concluding, a word or two must be added about a source of phosphates which cannot be considered of animal origin. Until the year 1879 iron obtained from ores containing phosphates even in very small quantities, as a great many iron-ores do, could not be used for the manufacture of steel because the metal retained the phosphorus, which contributed undesirable and deteriorating properties to the steel. In the year 1879, however, Messrs. S. G. Thomas and P. G. Gilchrist made known to the world their discovery of lining the vessel in which the iron is melted to convert it into steel with lime, or a mixture containing much lime, and also adding lime to the molten metal. This produces wonderful changes, the lime combines with the phosphorus to form phosphate, which then separates from the mass of molten metal and floats on the top along with other impurities, forming what is known as "basic slag." By this discovery much material, which had hitherto been useless for the purpose, could be employed for the manufacture of that extremely valuable material, steel, the quality of which was greatly improved by the removal of the phosphorus. What is more, this phosphorus, which was formerly not only absolutely useless but also a nuisance, is converted in this "basic" method of making steel into a valuable source of phosphate for the supply of that all-important plant constituent to our crops.

OUR MICROSCOPIC FOES.

By A. Winkelried Williams.

Of all the foes that are waging war against mankind the most dangerous and deadly are minute organisms belonging to the lowest orders of plant-life, and invisible to our naked eye. An immense number of these always surround us, and are ready to make an attack should they find a weak point in our defences.

Their presence in the air may be readily demonstrated by exposing some material upon which they can feed, and watching the result. The simplest method is to boil a potato, cut it in half, and immediately place one half under a bell glass purified by being washed in an antiseptic solution such as corrosive sublimate. Expose the second half to the open air for a short time, and place it also under a glass. Let them remain for a few days, and then examine. If the first half has been placed rapidly enough under the glass, we shall find it unaltered. On the second half, however, we shall see a number of small but growing spots, which will probably vary much in colour. These consist of colonies made up by immense numbers of the most minute plants, i.e., bacteria, and also of higher fungi. Certain species of the bacteria constitute our dreaded foes.

Bacteria are non-nucleated unicellular plants, which may be roughly classed into two divisions according to their shape, the circular forms being called micrococci, the elongated forms bacilli. In size they are most minute, being only visible under the highest powers of the microscope. Many are provided with cilia, by the lashing of which they are capable of independent movement. They are composed of a peculiarly resistant protoplasm, which is condensed at the surface, so that by the action of certain caustics they can be separated from many tissues on which they may be lying, the caustics destroying these tissues.

Bacteria have enormous power of reproduction, which is accomplished by division of the cells and fission. Many also form globular spores by a condensation of their protoplasm. The spores have a much higher power of resistance than the bacteria themselves, and may, under unfavourable circumstances, be quiescent while awaiting better times to take on full development.

Their *habitat* is almost everywhere. In water bacteria exist in great numbers; they are even found in springs at their sources. This indicates their presence in the soil, where they are found in great numbers. We have already seen that they exist in the air; but, being, for their size, heavy bodies, they are invariably attached to less dense particles of dust. Out at sea we find the air free from bateria, although in the water they abound. The higher we ascend the fewer we find. In towns the air teems with them, in the country but few exist. In the healthy living

body there are no bacteria, except in the alimentary canal and upper respiratory passages. It must not be supposed that all bacteria are the forerunners of disease; such is the case with only certain forms to which the significant term *Pathogenic bacteria* is applied. Many authorities assert that the non-pathogenic forms may, under certain circumstances, develop into pathogenic forms. This, however, has not been definitely settled, since we are only able to separate the different classes of bacteria by their action on cultivating media and on the living body. We have not yet been able to develop by cultivation a virulent form from a non-virulent, although we have by repeated cultivation diminished the virulence of some of the most malignant bacteria.

Of all the *Pathogenic bacteria* we have the most direful tale to tell. Of one discovered by Dr. R. Koch—namely, that of tubercle—the terrible ravages on human life by ferocious animals in India (over 24,800 fatalities per annum) are but trifling compared to the ravages stealthily done in our midst by this the smallest of the class of most minute living units. According to Dr. Koch's estimate one-seventh of the human race die of pulmonary consumption, and this is only one, certainly the most prolific, of the many diseases directly caused by the tubercle bacillus.

Happily for warm-blooded animals, these terrible death-dealers differ from most other bacteria, for although they can remain alive for some time outside the body, they are unable to *develop* in the outside world, and this considerably limits their number. A temperature above 96° Fahr. is necessary for their growth, and there are only a very few soils on which they can be cultivated, such as blood-serum and meat jelly. Moreover, they develop more slowly than other known bacteria, which may consequently outgrow them, and prevent their development. How, then, are we to account for the fact that tubercle is such a widely-spread disease, not only among all the races of men, but also among many of the lower animals? The consideration of the following facts answers this question.

The tubercle bacillus can form resting spores; consequently when once the tissues of a part have their vitality so lowered that the entrance of the bacilli is allowed, they can retain their hold with great tenacity. Although the bacilli cannot develop outside the body, their vitality is preserved for a long time; they have been found active in dried sputum as many as 180 days old. The sputum of consumptive patients swarms with bacilli, and great carelessness is often evinced in dealing with this. Certain animal products used for food, such as the milk of tubercular cows, contain the bacilli. Experiments, such as causing animals to inhale the tubercle bacilli, or the introduction of them into the blood, or sometimes the feeding on tubercular matter, result in tuberculosis.

Pulmonary consumption presents an example of the most typical way in which the tubercle bacillus performs its deadly work. In the majority of cases the bacilli are inhaled with the air, but may also infect the lungs by the blood carrying them from tuberculosis in other parts of the body. The bacilli are incapable of independent movement. This difficulty is too readily overcome in the body, as the streams of blood and lymph easily carry them along.

Their movement in the body may be aided by certain scavengers that are crawling about in our tissues and circulating in our blood, namely, the wandering cells of connective tissue and the white blood corpuscles. These take up the bacilli by wrapping their substance around them; then for a time they crawl about carrying with them the bacilli. In this attempt to devour the tubercle bacillus they often find they have caught a Tartar, who in turn feeds on and multiplies in them, and thus their wandering days soon end.

The bacilli and their secretions cause great irritation in the cells containing them, and also to the tissues around; as a result of this a most erratic growth of cells occurs, which pushes aside and causes atrophy of the normal tissues, thus forming a tubercle nodule. Blood-vessels do not form in the nodule; the central cells, deprived of their nutriment, and irritated by the secretions of the bacilli, die and coagulate into a cheesy mass, whilst at the periphery of the nodule the growth continues, and may join other nodules. In the cheesy centre the bacilli remain for a while, and their spores, when present, for a much longer time.

By-and-by one of these nodules may become softened, and work its way into an air passage, and the mass of tissue may be either coughed up or be drawn down as a fresh focus of mischief to other parts of the lung. As a result of this, if the nodule be large, a cavity is formed, which increases in size and joins other cavities. Blood-vessels may be broken into, causing bleeding and general infection of the system.

In this way a fatal state of affairs is brought about.

Tuberculosis may infect all parts and organs of the body, the process varying somewhat with the structure of the organ affected.

Many other diseases are also known to be caused by bacteria, such as anthrax, cholera, pneumonia, typhoid fever, erysipelas, leprosy, suppuration, and ordinary blood-poisoning. Before Sir Joseph Lister introduced the system of antiseptic surgery, bacteria were a most fertile source of danger in surgical operations by the decomposition and suppuration they set up in the wounds.

In this short paper it is impossible to describe the characteristics of any other pathogenic bacteria, but perhaps enough has been written to show the great danger to which we are exposed from attacks by an immense army of minute foes. Our defences against these will be the subject of another paper.

ON EARTH-WORMS.

By E. Mansel Sympson, M.A., M.B., Cantab.

LET us start by tracing the young earth-worm from its egg to adult life, we shall then see the relations of the stages through which it passes to other forms of animal life, and we shall get clearer ideas of the several parts and organs of the adult earth-worm. At starting, like everything else in the animal and indeed vegetable kingdom, the fertilised egg of the earth-worm is a mere tiny mass of jelly-like protoplasm—a peculiar compound of carbon, hydrogen, oxygen, and nitrogen, which has never yet been obtained save as a product of living bodies, and which forms the basis whence all organs, nay all cells, in the living world have sprung. This mass of protoplasm is called a cell, and has a smaller mass of somewhat altered protoplasm and nucleus inside it. It is laid in a case or cocoon, of somewhat the same structure as a beetle's wing, which has probably been secreted by a large gland in the upper end of the earth-worm's body. Soon the one cell begins to divide into two, and these into four, and so on, till, eventually, what was the egg-cell consists of a great number of cells, all, however, just alike. In the next stage these cells become arranged in two rows or layers, and all of those in one layer are larger than those in the other. The little animal so formed becomes concave, hollowed out on the side formed by the larger cells, until it assumes the form of a sac, with an opening—the future mouth—at one end, the cavity of the sac being the primitive alimentary canal, lined

by the large cells, called the hypoblast, while the small cells, known as the epiblast, form a kind of primitive skin round the animal, and possess each little filaments called cilia, serving for locomotion. These two layers pass

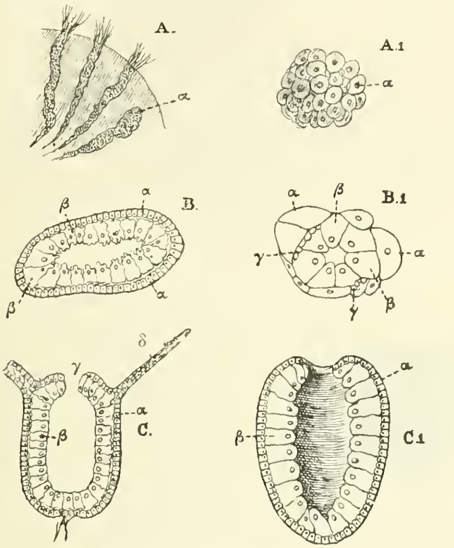


Fig. 1.
A. Protozoon-Ophrydium. α, retracted. A1. Earthworm, 1st stage. α, nucleus. B. Metazoon—Hydra, transverse section through body A–B. α, ectodermic or epiblastic cells; β, hypoblastic cells. B1. 2nd stage, transverse section. α, epiblast cells; β, hypoblast; γ, mesoblast. C. Longitudinal section. α, epiblast; β, bypoblast; γ, mouth; δ, tentacle. C1. Vertical section. α, epiblast; β, hypoblast.

into one another at the oval, or mouth-opening. The outer layer is the organ of support of locomotion (by the cilia) and may be the seat of the respiratory functions. Let me here remind you that the frog—so highly developed compared with our earth-worm—under certain conditions breathes largely by means of its skin. Also, in so far as this outer cell-layer perceives the state of the surrounding medium—that is, the air, water, or earth wherein it dwells—it is an organ of sensation too. The inner layer is nutritive in function; it produces changes in the food which is taken in, and allows what can be turned to useful account to pass into its cells, and these in their turn feed the outer layer of cells. What is useless is passed out again by the same opening whereby it entered. As the functions of the two layers are different, so also the form of the cells differs in each layer. And here we may pause for a moment to compare these stages with what we know of the animals lower in the scale than earth-worms—*i.e.* the Protozoa and the Cœlenterata. One great law of development is this: that each animal, in the commencement of its separate life, passes through stages which are permanent among animals lower than itself. There are two great classes of animals: the Protozoa, which includes the Amœba, the Infusoria, and the like; and the Metazoa, wherein are all other kinds of animals. One of the facts which mark off the first class from the second is that a protozoon may consist of any number of cells; but those cells are not different from one another either in form or function. It is very interesting to compare one of these, say ophrydium, with the earth-worm's egg in its early stage. In both you will find many cells cohering together, but in neither will there be the least difference in the cells themselves or in what they do. This process of cell-division in the egg may therefore be explained as a survival transmitted from early ancestors. Now the metazoa are characterised by having at least two layers of differentiated cells in their embryos. There is the cœlenterata, which contains the common hydra of ponds, the fresh-water polyp, the jelly-fishes, and the sea-anemones. Let us take one of these, say a hydra, and set it beside our young earthworm, this bag, with its double layer of cells, for a coat, and we find that, as far as form and functions go, they are almost the same. Our hydra is nothing else than a stomach-bag with a double coat, set on a stalk and furnished with tentacles. There could hardly be a better illustration of the law of development I have just mentioned. Later on, a third layer of cells may be seen, the mesoblast, between the other two.

It is a universal rule that from the outer layer of cells (the epiblast) are derived the whole of the nervous portions of an animal's body, as well as the skin and the lining membrane of the mouth, while from this mesoblast, or middle layer, come the muscles, bones, connective tissue, and the like. From the hypoblast is derived the epithelium of the alimentary canal and of all the glands which are in connection with it, such as the spleen, liver, and pancreas.

Very soon the mesoblast of our young earth-worm on one side of the bag-like structure becomes divided into a number of square masses, disposed quite regnlarly on each side of the middle line on the under surface of the animal. Also, along this line, the outer layer of cells

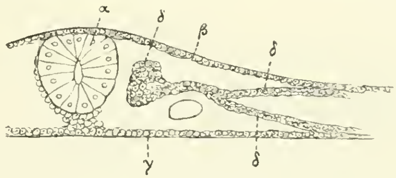


Fig. 2.
α, nerve cord; β, epiblast; δ, mesoblast; γ, hypoblast.

thickens upwards and inwards, and from this is formed the nerve-cord which runs the whole length of the body. From it is derived the brain and spinal cord of a mammal. At the same time, each of these square masses becomes hollow in the centre, and somewhat like a sac itself. The adjoining walls of each of these sacs fuse together, and here you have a trace of the division into segments, which is common in the animal kingdom, and which is shown in man by the transverse bands across the abdomen. These sac walls are represented outside on the body of the earth-worm by the transverse rings. On the under surface of the first segment is the mouth; we distinguish one surface from the other by the lighter colour of the lower one, and because on it in each segment are four pairs of hairs or setæ. These are of great importance to the animal: by their aid it can get over the ground at a tolerably rapid rate, and when once partly in its burrow, it holds so fast that it cannot be pulled out without being torn in pieces. I mentioned the gland—the clitellus—it shows as a thickening of the skin between the twentieth and thirtieth segments. This secretes a kind of viscid gumlike fluid, which hardens and envelopes the egg like the case of a cocoon. Let us now look at the digestive system by the aid of the following diagram. At the upper end you find the mouth, with a sort of lip to it, which is useful for catching hold of food. Next comes a strong

muscular pharynx, which is pushed forwards as the animal eats. Below this the canal narrows into the gullet—the œsophagus, into which open three several pairs of glands, secreting a surprisingly large quantity of carbonate of lime. Nothing like them is known to exist in any other animal. They are very richly supplied with blood, so that at first sight even one feels sure they must serve some important purpose in the animal's economy. That purpose is probably twofold in character; they serve as organs of excretion, that is, to cast out of the body something which is useless or actually harmful; and secondly, they directly aid digestion. You will almost always find an accumulation of carbonate of lime, sometimes in crystals, sometimes in little almost shapeless lumps, and you don't find those worms which live in chalky soils and whose intestines are full of chalk, with smaller or less well-filled glands, so we may fairly argue that the lime is an excretion. Again, worms live largely on fallen leaves, as we shall see presently, and these contain a large amount of lime, of no use to the tree, which gets rid of it in this way. Secondly, the half-decayed leaves generate in themselves various kinds of acids; the secretion of the earth-worm's alimentary canal is alkaline, and it is believed that these masses of lime neutralise the acid food so as to allow the alkaline secretion to have fair play. On passing on from these glands one finds that the canal swells out into the crop, and a little lower down into the gizzard, which the worm uses as a fowl uses its gizzard to crush and reduce to a pulp hard food. To assist this, the bird swallows gravel and small stones. Our earth-worm has no teeth, and not even a beak; its gizzard is formed of very strong circular muscles, and generally encloses a store of sand and tiny stones. From the gizzard, the intestine, which has a number of dilatations on each side, runs in a straight line to the vent at the posterior end of the body. From its upper surface all along proceeds downwards into it a dip or involution—the typhlosole—serving to extend the absorbent surface very greatly. The nervous system of the earth-worm is very simple. In the third segment, overlying the pharynx, are two ganglia united together; from these nerves run to the mouth and skin of the first segment. These ganglia are supposed to represent the brain of a higher animal. From these, two nerve-cords run round the pharynx to the ventral surface of the intestine; they join there, and run the whole length of the body, swelling at every segment into a gangliform enlargement, whence two pairs of nerves are given off on each side, while from the intermediate nerve cords one pair supplies the deep muscles. We may consider this ventral nerve-chain as comparable to the spinal cord of higher animals, while a tiny nerve-filament—the so-called stomato-gastric—coming from the supra-œsophageal ganglia dorsally over and to the intestine, is the equivalent of the sympathetic system. With regard to the vascular system, there are two kinds of blood in the earth-worm. Mr. Busk put forward the ingenious idea that in the blood of mammals there may be a division made into two functional parts, *i.e.*, that of the red corpuscles, which are carriers of oxygen, and the white corpuscles and plasma, conveying nourishment to the tissues. This idea has also been supported with his accustomed vigour by Ray Lankester. In the vessels of the earth-worm *red* blood is very extensively supplied to the skin (a breathing organ), while a colourless plasma with white cells in the segmental chambers bathes all the visceral organs. The division of function which has been suggested is rendered probable by the analogy of the worm, though not certainly proved. As regards the blood-vessels, a dorsal one—rhythmically contractile—runs the whole length of the animal's body; there is also a sub-intestinal and a sub-neural one, all of which communicate with each other, and in the eighth to the sixteenth segments these communications are called hearts.

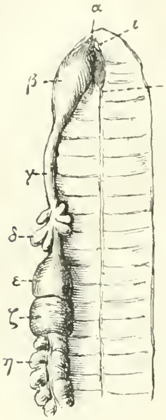


Fig. 3.
From a dissection.
α, mouth; β, pharynx; γ, œsophagus; δ, calciferous glands; ε, crop; ζ, gizzard, η, intestine; ι, supra-œsophageal ganglia; κ, double nerve-cord.

(To be continued.)

SOME PROPERTIES OF NUMBERS.

By Robt. W. D. Christie.

Take any multiple of 7 having two digits only, then we may place any other figure on each side, and the number with four digits thus obtained will also be a multiple of 7: *e.g.*, suppose we take 21 or 28 or 35, then 1211, 2212, 3213, 4214, 5215, 6216, 7217, 8218, 9219, &c., are all multiples of 7; so also 1281, 3283, 5285, 3353, 4354, 6356, &c., are divisible by 7 without remainder.

The same principle applies to multiples of 11 or of 13: *e.g.*, let us take 33, 55, 77; 26, 52, 78. Then the numbers 1331, 4554, 6776; 4264, 7527, 9789 are multiples of 11 and 13 respectively.

The same principle applies to numbers having *eight* digits (or $6m-4$ digits): *e.g.*, 12345676 is divisible by 7; consequently 1123456761, 2123456762, 3123456763, &c., are also divisible by 7.

We need not confine the principle to numbers of two or eight digits: *e.g.*, we know that 567 is divisible by 7; so also is 14679. Here I place 9 on the right side, according to the rule, but instead of placing 9 on the left side I add $9+5$ to get 14. Again, 234 is a multiple of 13; so also is 9347 for the same reason. Again, $2678=13M$; so also is 31785. Here $26+5=31$, and so on for any number of digits. The figure placed on each side need not necessarily be the same. Any figure of the *same form* will do equally as well. Thus 8211, 2219, 17213, 144214, &c. Here 8 is of Form $7M+1$, 144 of Form $7M+4$, &c. In applying this principle, though we may have any number of figures on the *left*, we are restricted to one figure on the *right* hand. The proof is easy. Let $N=7$, 11, or 13.

We have $10b+c=N(M_1)$ by hypothesis.

Therefore $10^2b+10c=N(M_2)$ . . . . (1)

Also $10^3a+a=1001a=N(M_3)$ . . . . (2)

Thus $10^3a+10^2b+10c+a=N(M)$. Q.E.D.

(2) If we take any number with 6 digits (or $6n$ digits), having remainders 1, 2, 3, 4, 5 or 6 when divided by 7, we may by prefixing 6, 5, 4, 3, 2, 1 respectively obtain an exact multiple of 7: *e.g.*, the number $123456\div7$ has a remainder 4. Therefore $3123456=7M$. Here we have $7-4=3$. Again, 123456, when divided by 13, has 8 for remainder. Therefore, since $13-8=5$, we have $5123456=13M$. Similarly, $123456789012=13M+11$. Therefore $2123456789012=13N$.

(3) Take any number of two digits and double it. The four figures placed side by side are divisible by 17.

Thus 1224, 3570, 4692=17M.

If we proceed, as in (1) *supra*, we need not confine the principle to figures of two digits. Thus $53 \times 2 = 106$.

Therefore 5406=17 M. Here 53+1=54.

Again, $1234 \times 2 = 2468$. Therefore

$$\begin{array}{r} 2468 \\ 1234 \\ \hline 125868 = 17\text{M}. \end{array}$$

If we take care to leave untouched the two figures on the right, and place the other figures, as in the example, the principle will extend to any number of digits. This is easily proved thus:—Let t signify *ten*.

Then $(at+b)(t^2+2) \equiv 17\text{M}$,

i.e., $at^3+bt^2+2at+2b \equiv 17\text{M}$. Q.E.D.

Also, since $(at^2+bt+c)(t^3+3) \equiv 17\text{M}$,

Therefore $at^5+bt^4+ct^3+3at^2+3bt+3c \equiv 17\text{M}$.

This means that if you multiply a number of *three* digits by 3 and place the *six* figures side by side, the number is then divisible by 17.

(4) Similarly, if we take any number of three digits and double it, the figures placed side by side are exactly divisible by 167. Thus $123 \times 2 = 246$. Then 123246=167 M. Similarly $234 \times 2 = 468$. Thus 234468=167M. Nor need we confine the number to three digits, if we proceed on the principle given above. Thus $6789 \times 2 = 13578$. Therefore 6802578=167M, since 6789+13=6802, &c. The proof is similar to that of No. 3, and the principle is of wide application. *E.g.*, we may take any 5 figures and double them: the ten figures are divisible by 7. Thus

1862937258=7M.

(5) A general principle applicable to all numbers ending in 1, 3, 7, or 9 is as follows *:—

Take any number, say, 123456789=13R+1. Then

1123456789 or 12123456787,
2123456790 or 1112345678б,
3123456791 or 10123456785,
&c. &c. &c. *ad infin.*

are all divisible by 13, without remainder.

Again, take 12349=7M+1.

Then
412349 or 312347,
812350 or 612346,
1212351 or 912345,
1612352 or 1212344,
&c. &c. *ad infin.*

are all exactly divisible by 7.

It will be readily perceived that the prefixes 4, 8, 12, 16, &c., also 3, 6, 9, 12, &c., are in arithmetical progression, as also the figures in the unit's place. The principle may be briefly stated in mathematical language as follows:—

$$\text{np } 10^m + \text{N(M)} + \text{n} = \text{N(R)}$$

where N and n are any integers; m the number of digits, p the prefix. The proof is not difficult. We know that 21, 301, 1001, 50001, 400001, 6000001, are divisible by 7. These prefixes 2, 3, 1, 5, 4, 6 follow the law $5p_n - 7x = p_{n+1}$. Thus $5 \times 2 - 7 = 3$, &c.; and these values recur.

Thus if $\text{N} = n(\text{R}) + 1$ by hypothesis say $22 = 7(\text{R}) + 1$,
And we know that $pt^m + 1 = n(\text{R}_1)$ say $301 = 7(\text{R}_1)$,
Then $pt^m + \text{N} = n(\text{R}_2)$ or $3 \cdot 22 = 7(\text{R}_2)$,
Also $2pt^m + \text{N} + 1 = n(\text{R}_3)$ or $6 \cdot 23 = 7(\text{R}_3)$;
Also $3pt^m + \text{N} + 2 = n(\text{R}_4)$ or $9 \cdot 24 = 7(\text{R}_4)$.
Thus $npt^m + \text{N} + n - 1 = n(\text{R}_5)$,
or, since $\text{N} = n(\text{R}) + 1$,
$np10^m + \text{N(R)} + n = \text{N(R)}$.

Similarly for any prime number, say 19, the prefixes are 17, 15, 11, 3. 6, 12, 5, 10, 1, according to the law $19_r - 2^n$, and the values recur after $\frac{\text{N}-1}{2}$ values.

* Multiples of these numbers only can have *all* the digits in the units place. Even numbers cannot nor those ending in 5.

(6) It is not difficult to get the prefixes without actual trial or division, *e.g.*, What prefix will make the number 123456789 exactly divisible by 7?

Our formula for seven is $7x - 3^n r$, *i.e.* $7 \times 4 - 3^3 \times 1 = 1$. Therefore 1123456789 is exactly divisible by 7.

Again, what prefix will make 123456789 exactly divisible by 13? Our formula for 13 is $13x - 4^n r$, *i.e.* $13 \times 5 - 4^3 \times 1 = 1$. Therefore 1123456789 is also exactly divisible by 13. What prefix will make 1236 divisible by 19? Using our formula for 19, viz. $19x - 2^n r$ we get $19 - 2^n = 3$. Thus 31236, 61237, 91238, &c., &c., *ad infin.* are divisible by 19.

A few useful formulæ are—

$$2^n\, 10^n - 1 = 19\text{R}.$$
$$3^n\, 10^{6m-n} - 1 = 7\text{R}$$
$$4^n\, 10^{6m+n} - 1 = 13\text{R}.$$

(7) No. (5) *supra* enables us to obtain a convenient test for divisibility by any prime 75, *e.g.*:—

If 1234563=19M, then 123456=19M +13.
Therefore $123443 = 19\text{M}_1$ and $12344 = 19\text{M}_2 + 13$.
Then $12331 = 19\text{M}_3$ and $1233 = 19\text{M}_4 + 17$.
Thus $1216 = 19\text{M}_4$ and $121 = 19\text{M}_5 + 7$.
Therefore $114 = 19\text{M}_5$, &c.

The proof is simple. We have

$19 \times 9 = 171$	$19 \times 4 = 76$
$19 \times 8 = 152$	$19 \times 3 = 57$
$19 \times 7 = 133$	$19 \times 2 = 38$
$19 \times 6 = 114$	$19 \times 1 = 19$
$19 \times 5 = 95$	

If a number then end in any digit, say 3, and is also divisible by 19, then the other figures (however numerous) are of the Form 19M+13.

We see also from the table that if we multiply any of the digits by 17 and reject $19x$, we get the figures on the left.

A similar law applies to any of the primes. Hence the rules.

Let us test the number 123454 for 17.

Since $17 \times 3 = 51$ our multiplier for 17 is 5.

Say, then, $5 \times 4 = 20$, reject 17, leaving 3 and 3 from the next figure 5=2, thus $12342 = 17\text{M}_1$.

Proceeding, say $5 \times 2 = 10$ and subtract, leaving $1224 = 17\text{M}_2$.

Proceeding again, say $5 \times 4 = 20$, reject 17=3 and take 3 for $122 = 119 = 17\text{M}_3$.

Since the last result is true, therefore 123454 is a multiple by 17.

After a little practice the process can be gone through rapidly.

(8) It is generally known that we may square any number ending in 5 as follows:—Square 65. Here $5 \times 5 = 25$; $6 \times 7 = 42$. Thus $65^2 = 4225$. But it is not generally known, as can be easily proved mathematically, that the same principle applies to any two numbers whose tens' digits are alike, and whose units equal 10, *e.g.* multiply 86 by 84. Here $8 \times 9 = 72$; $4 \times 6 = 24$.

Therefore our result is 7224.

Again, multiply 177 by 173. Here $17 \times 18 = 306$; $7 \times 3 = 21$. Therefore the result is 30621.

Messrs. Murray have sent us a new and cheap edition of Darwin's "Voyage of the *Beagle*," the copyright in which appears now to have run out. Probably no book has done more to make naturalists than this simple narration of Darwin's earlier travels and observations.

PHOTOGRAPHS OF NEBULÆ.

By A. C. RANYARD.

THE SPIRAL NEBULA IN URSA MAJOR.

81 Messier (G.C. 1949).

As shown on Mr. Isaac Roberts' photograph, this is a fine example of a spiral nebula, though up to the date of his photograph its spiral character had not been recognised. Dr. Copeland, using the Earl of Rosse's 3-foot reflector, describes it as very like the great nebula in Andromeda, though at the time of the observation (1871) the spiral character of the Andromeda nebula had not been recognised. With the 6-foot reflector in 1874, he found that the nebulosity extended about eight minutes of arc from the nucleus towards the north, and that the fainter portion was elongated in the north preceding and south following directions. He describes it as "extremely bright, very suddenly very much brighter in the middle to a nucleus." From Mr. Roberts' photograph it is evident that the plane of the spiral is inclined to us, so that the longer axis of the ellipse into which it projects is inclined in a north preceding and south following direction, as described by Dr. Copeland. The longer diameter of the ellipse is more than sixteen minutes, so that Dr. Copeland must have seen the parts of the nebula which Mr. Roberts' photograph shows to break up into spiral streams. Upon the stream lines of these faint spiral arms are a number of nuclei or possibly small stars, which reminds one of the arrangement of stars on the stream lines of the Andromeda and Canes Venatici nebulæ. There are no outlying smaller nebulæ, in the immediate neighbourhood of this spiral nebula as in the case of both the above-mentioned larger spirals. But the spiral structure of this nebula seems to be more regular. But about 42 minutes to the north of it lies a most remarkable elongated nebula known as 82 Messier (G. C. 1950). Towards its centre are two nuclei, each of which are double. The ray is divided in a transverse direction by two very marked dark channels. Ingall describes it in the *English Mechanic* for December 18, 1885, as having a twisted appearance like a "distaff of flax." The longer axis of this remarkable nebulous ray is inclined in a north preceding and south following direction. Huggins has found the spectra of both these nebulæ to be continuous, but deficient towards the red end.

THE SPIRAL NEBULA IN CANES VENATICI.

51 Messier (G.C. 3572).

This interesting nebula has been drawn by, amongst others, Sir John Herschel (see "Phil. Trans." for 1833), Lord Rosse ("Phil. Trans." 1850), Lassell ("Memoirs of the R.A.S.," vol. xxxv.), and by Vogel (see "Potsdam Observations," vol. iv.). Sir John Herschel's drawing only shows a partly split ring round a nebulous centre, with a small detached nebula to the north. Smaller instruments only show two unequal nebulæ nearly in contact. Sir John Herschel had an idea that there was an analogy between this nebula and the split ring of the Milky Way; but we now know that the nebula has a most complicated form. In addition to the spiral streams about the chief nucleus, there is a curved nebulous stream which joins the secondary nucleus towards the north, and an appearance as of a smaller spiral system about one of the stellar points on the preceding branch of the great spiral. The aggregation of stars or nebulous masses along the stream lines of nebulous matter is very marked. The smaller nebulous mass towards the north is cut off sharply on the following side. The nebulous stream which joins it to the great spiral comes up to its northern side; and on Mr. Roberts' negative there is an appearance of spiral structure even about this smaller nebula. Mr. Common obtained an excellent photograph of this nebula with his 3-foot reflector at Ealing about four years ago. The nebulous streams of this complicated structure are so marked that they were recognised by observers before the photographic era. The Earl of Rosse's drawing is perhaps the best of any made with his great telescope. It shows nebulous matter filling up the spaces between the great streams more than any other drawing. Mr. Lassell's drawing, and the one made by Dr. Vogel with the 27-inch refractor at Vienna, are also very good. Dr. Huggins finds the spectrum continuous.

THE DUMB-BELL NEBULA IN VULPECULA.

27 Messier (G.C. 4532).

The brighter parts of this nebula are very conspicuous, and in a small telescope resemble a dumb-bell in form, hence its popular name. It has been figured by a great many observers, amongst others Sir John Herschel, in the "Phil. Trans." for 1833; by the Earl of Rosse, in the "Phil. Trans." for 1844, 1850, and 1861; by Secchi, in the "Memorie dell' Osservatorio del Collegio Romano," 1852–55, plate iv.; by Smyth, in the "Speculum Hartwellianum," p. 290; by D'Arrest, in the "Instrumentum Magnum Æquatoreum;" by Trouvelot, in vol. vii. of the "Annals of the Harvard College Observatory;" and by Vogel, in vol. iv. of the "Publications of the Potsdam Observatory;" and by Ingall, in the *English Mechanic* for December 1874. Mr. Lassell gives a map of the stars in and about the nebula on a scale of 100 seconds to the inch in vol. xxxv. of the "Memoirs" of the R.A.S.

Mr. Roberts' photograph shows a brighter edge to the northern lobe of the dumb-bell, which is not shown in the drawings. The fainter nebulous matter, which forms the background on which the dumb-bell is seen, projects beyond the elliptic outline. It appears to be structureless, but the brighter region of the nebula breaks up into curdling masses of greater density. Several stars are seen projected on the nebula, one nearly centrally. The drawing which appears to me most nearly to represent the appearance seen on Mr. Roberts' negative is that by Father Secchi. According to Dr. Huggins, the spectrum of this nebula consists simply of one bright line.

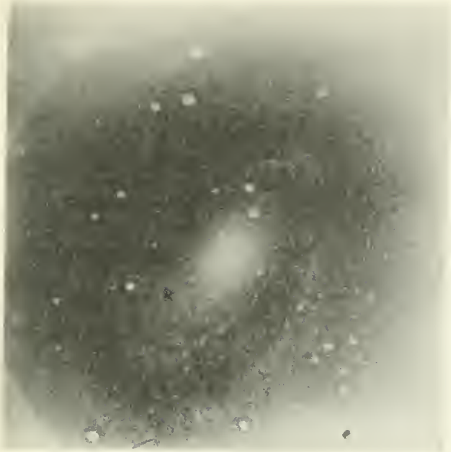
STAR-BORN METEORS.

BY THE LATE RICHARD A. PROCTOR.

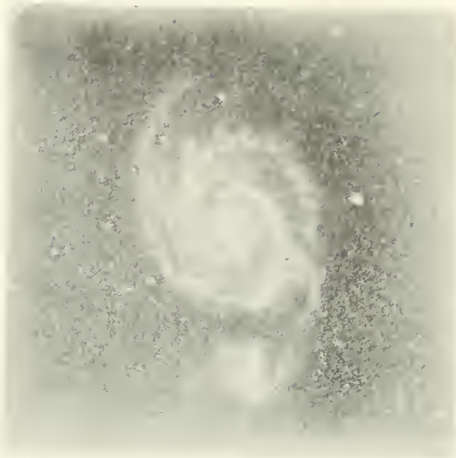
(*Continued from p.* 16.)

SUCH was the position, on the one hand of meteoric astronomy, and on the other of the various theoretical conclusions which were either demonstrably deducible from discovered facts, or seemed more or less probable as viewed in their light. Putting all theory aside, so much as *this* was certain, and is certain,—among the meteoric streams encountered by the earth each year, some are undoubtedly travelling in elliptical orbits around the sun; and among these some are as certainly following in the tracks of known comets. Moreover, among all the paths thus *determined*, none are of such extent that the velocities of the meteors where they cross the earth's track exceed enormously the velocity of the earth in her orbit.

This being so, students of meteoric astronomy heard, with some surprise, an announcement by Mr. Denning four or five years ago, that he had discovered certain systems of meteors which could not possibly be explained by anything thus far demonstrated respecting these bodies. It was not in such terms, indeed, that he announced his discovery, but that was undoubtedly what it amounted to. He stated that

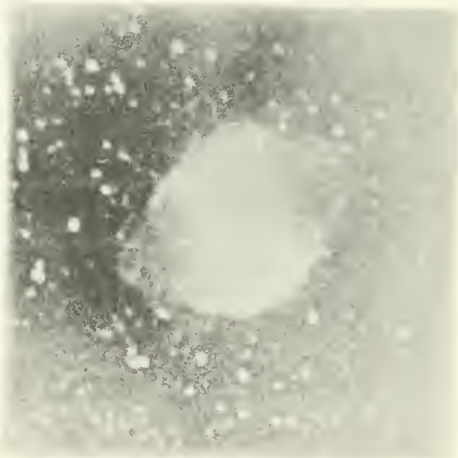


81. Messier, IX. h. 47 m. 12s., N., 69° 41′ (1900). Spiral nebula in Ursa Major, enlarged about 5 diameters from a negative by Mr. ISAAC ROBERTS, taken 31st March, 1889, with an exposure of 4 hours.



51. Messier, R.A. XIII h. 25m. 27s., N., 47° 42′ (1900). Spiral nebula in Canes Venatici, enlarged about 8 diameters from a negative by Mr. ISAAC ROBERTS, taken 21st April, 1889, exposed for 4 hours.

81 & 82. Messier, enlarged about 1¾ diameters from a negative by Mr. ISAAC ROBERTS.



27. Messier, R.A XIX h 55m 3s., N., 22° 27′ (1900) The Dumb Bell nebula in Vulpecula, enlarged about 8 diameters from a negative by Mr. ISAAC ROBERTS, taken 29th April, 1889, with an exposure of 4 hours.

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some meteor flights radiate from the same small region or radiant point for several months in succession! If we consider what this means, we shall see at once how utterly irreconcilable it is with what had been discovered respecting other meteor systems. In the course of three months the direction of the earth's path changes through a right angle. Thus, while on December 20 the earth is travelling along at the rate of $18\frac{3}{4}$ miles per second towards a point between the stars Eta and Beta of the constellation Virgo (a little south of such a point), three months later the earth's course is directed almost exactly towards the star Mu of the constellation Sagittarius—three signs, or a quarter of the full circuit of the heavens, away from the first-named point.* Now the earth's motion in her orbit being thus rapid, had always been taken into account in inferring the real direction of the motion of meteors as they entered her atmosphere, from the course on which they appeared to travel. Although a meteor travelling on a very eccentric orbit—one of the November or August meteors, for example —might have a velocity of 27 miles per second on its own orbit, yet the effect of such a motion as the earth has, about five-sevenths of the velocity of the meteors themselves, could not but largely modify the apparent direction of their tracks as they entered our air. In point of fact, just as when we are rushing swiftly along, in an open carriage, through a heavy rain-shower, the rain-drops seem to meet us more fully than they actually do, and we lower an umbrella in front as if the rain were driving nearly horizontally in our faces, so, whatever the real direction of a flight of meteors, it always seems to come from a radiant nearer by many degrees to the point towards which the earth is travelling than is actually the case. Thus the November shower, which really crosses the earth's track at a considerable angle, in a direction opposite to that in which the earth is travelling—the meteors moving with velocities of about 26 miles per second—*appears*, in consequence of the earth's swift motion, to come from a point in the constellation of the Lion not very far from the point towards which the earth is advancing, and the meteors rush into the air of the swiftly advancing earth at an apparent rate of fully 44 miles per second. Now, if we suppose our earth's course suddenly changed through a right angle, when she is in the midst of this flight of meteors, it is clear that the apparent velocity and direction of their entry into our atmosphere would be largely altered—the apparent velocity would no longer be increased by a rapid motion of the earth *towards* the advancing meteors, and the radiant would no longer be shifted nearer to the point of the star-sphere, towards which, *before the change*, the earth had been advancing. The new radiant point for the star-shower would lie many degrees from that point in the Lion (in the midst of the group called the Sickle in Leo) from which the November meteors appear to radiate. So with the August meteors, and with any system known to be travelling on a closed orbit, no matter how enormous its extent, for no meteor so travelling can cross our earth's track with a greater velocity than 27 miles per second, and the earth's velocity of $18\frac{3}{4}$ miles per second bears so great a proportion to such meteoric velocity that every change in her direction must in large degree affect the apparent direction of meteoric motion.† So that if a meteor-stream were so wide that the earth took several days in traversing it, the radiant point of the meteoric paths would shift quite largely among the stars. This is no mere theory, but absolutely certain,—indeed a very simple deduction from obvious geometrical relations. Just as certainly as a gale seems to change its direction when a steamer exposed to it changes her course through any considerable angle, so certainly would the apparent direction of meteoric motion seem to change as the earth changed her course, if she were several days in passing through the stream. And, as a matter of fact, in the few cases where the earth does occupy several days in passing through a meteoric system, such a change of the radiant point of the system is observed to take place. Thus, the August meteors, though their time of greatest frequency is about August 10-11, are visible from July 25, when the first few stragglers appear, to August 20, when the last are seen. During this time the radiant of the system changes about 42 degrees in position on the celestial sphere, or nearly half the distance which separates the point overhead from the horizon.

What, then, are we to understand from the persistence of the radiant point of a meteor-system during three or four months? If actually demonstrated, such persistence would show, beyond all possibility of doubt or question, that the earth's velocity of $18\frac{3}{4}$ miles per second is so small, compared with the velocities of the meteors thus seen, as not appreciably to affect their apparent direction. Just as swift motion in a carriage appreciably affects the direction in which rain seems to fall, but would not appreciably affect the direction in which bullets fired at the carriage from a battery would seem to strike, so the rush of the earth at the rate of $18\frac{3}{4}$ miles per second must markedly affect the apparent motion of meteors travelling on closed orbits round the sun (seeing that these cannot travel more swiftly than 27 miles per second); but this motion of the earth would not affect in any recognisable degree the apparent motion of meteors travelling with velocities of several hundred miles per second athwart the earth's track. But then, to cross the earth's track with such velocities, meteors must be travelling on other than closed or elliptic orbits. In other words, they must be travelling on hyperbolic paths, coming to our system from athwart the interstellar depths with velocities greatly exceeding those the sun can communicate by his attractive might, or than he can control in bodies at the earth's distance, and so passing away on another interstellar journey to visit some other star system; flitting thus from sun to sun, but not to be retained within the domain of any.

Now it appeared to me, and also to all who had mastered and understood the theory of meteoric motions as hitherto observed and demonstrated, that the inference thus certainly deducible from Mr. Denning's discovery, if real, was so utterly improbable as to render his discovery exceedingly doubtful. I, for my own part, regarded it as far more likely that Mr. Denning had been deceived by accidental coincidences than that he had really observed that which would have had so marvellous, one may say so astounding, an interpretation. I had often spoken in my lectures of comets and meteors flitting from star to star, and had in several essays mentioned such bodies as undoubtedly existing. In my essay on Gravitation in "The Expanse of Heaven" I had calculated the time which meteoric bodies

* See my "Seasons Pictured," from the zodiacal maps in which the point towards or from which the earth is travelling at any moment can be readily determined.

† To show this, draw a line 27 inches long, and at right angles to it from one end a line $18\frac{3}{4}$ inches long (the real proportion is that of the diagonal to the side of a square), and around the point where the two lines meet describe a circle having the shorter line for radius—then lines from the other end of the longer line to different parts of the circumference of this circle vary as much as the apparent paths of meteors would seem to vary if the earth's motion were varied through all possible directions (its velocity remaining unchanged), while within a meteor-stream, travelling at the rate of 27 miles per second. The full amount of apparent change of direction would be no small angle, but one whole right angle!

would take to travel from the nearest star to our own system; while in my essay in the *North American Review* on the Origin of Comets and Meteors I had spoken of many meteoric bodies as certainly reaching our earth from the interstellar depths, and primarily from the interiors of the fixed stars. But the idea had not presented itself to my mind that streams of meteors from remote suns could retain after their journeys across the interstellar depths velocities of many hundred miles per second, or that such streams could at our distance from even the nearest stars retain so much of the character of streams that the passage of the earth through any such system should indicate the position of their radiant point. Still less did it seem likely to me that such streams should remain recognisable by meteors observable not only for several successive months in one year, but during several successive years.

Thus, like Professor Alex. Herschel, Mr. Greg, and others, I regarded Mr. Denning's observations as insufficient to establish so marvellous a result as they would unquestionably demonstrate if accepted. I did not reject them; but it appeared to me that they should not be accepted until overwhelming evidence had been obtained in their favour. Thus I waited, though fully recognising the validity of what Humboldt said in his "Physical Description of the Heavens," speaking, more than a quarter of a century ago, on this very subject:—"The progress of our knowledge, respecting igneous meteors," he said, "will be the more rapid the more impartially facts are separated from opinions, so that while carefully sifting or testing all particular facts on the one hand, we may not, on the other, fall into the error of rejecting, as bad or uncertain observations, whatever results we are not yet able to explain." "It appears to me most important," he went on, "to separate physical relations from those geometrical and numerical relations which admit, generally speaking, of more certain and assured investigation." Only, it is to be noticed that the trouble with Mr. Denning's observations was not at that time that they were not easy to explain. Mr. Denning himself appears still to imagine that this is the difficulty. The real source of perplexity lay, and the real interest of his discoveries lies, in this, that they can bear but one explanation, and that that explanation is so singular and so interesting.

There is, as I pointed out to Mr. Denning four years ago, but one explanation of a meteor-stream having an unvarying radiant for several months in succession—viz. this, that the component meteors are travelling on parallel paths through the interstellar depths, and cross our solar system with such velocities, that during their passage athwart the domain of the sun their paths are hardly deflected at all, at least until they are far within our earth's distance from the sun. Thus the earth's atmosphere receives them on nearly parallel paths; though perhaps such as fall on Venus and on Mercury may have had their directions appreciably altered, because of the more energetic solar attraction to which they have been exposed. For the same reason that the influence of the sun at the earth's distance does not affect the real course of these swiftly-travelling meteors, the varying direction of the earth's motion does not influence their apparent direction; a velocity of $18\frac{3}{4}$ miles per second is as nothing compared with the swift rush of those meteors through space.

It was because of the unlikely nature of this—the only possible explanation of Mr. Denning's discovery—that until the discovery should be confirmed by sufficient evidence I regarded it as doubtful. As a problem of probabilities, the unlikelihood of the conclusion certainly deducible if the observations were trustworthy, overbalanced then the evidence—strong though it seemed—in favour of the facts supposed to have been observed.

Observations have now, however, continued long enough to make further doubt respecting their *general* validity unreasonable, and the balance of probabilities is so far turned the other way that we may begin to inquire *in what degree* the observations may be accepted. Carefully weighing the evidence gathered by Mr. Denning himself, and combining it with that which Messrs. Greg, A. Herschel, Konkoly, and others have obtained, the probability of error, or that merely accidental coincidence is in question, becomes so small, that even the seemingly immense unlikelihood of the conclusion to which the observations unmistakably point, disappears. We have to accept the observations, and with them the inferences deducible from them. We learn that: *Besides the meteors which form systems travelling on closed paths around the sun, besides those meteors which had been recognised as coming from interstellar space with velocities not greatly exceeding those which our sun can communicate to bodies approaching him from a distance, and besides those less certainly recognised which have been regarded as ejected from the earth herself in past ages, there are some which reach our solar system with what may be described as extra-planetary velocities—with velocities so great that the earth's velocity in her orbit is by comparison small.*

Only, it must be remarked that Mr. Denning's observations cannot be accepted as interpreted by him. (I am not referring to any explanation he offers, for he offers none—seeming, indeed, to be of those who lose interest in observations, even their own—when apparently pointing to anything so unworthy of esteem as new truths.) He speaks of his "radiants" as *stationary*, which is impossible. When pushed, he claims to determine them within a couple of degrees. It is not only altogether unlikely that they change so little as this, it is absolutely impossible that Mr. Denning, or even Mr. Greg or Professor Herschel, could determine the radiant point of meteors, even during a one-night shower, within five or six degrees. If we admit that some radiants seem to change so little, in several months, as to indicate velocities up to one hundred miles a second, that will correspond with Mr. Denning's observations — as reasonably interpreted—and be quite remarkable enough even then.

Schiaparelli's vague guess respecting the origin of meteors (oddly described by Professor Young as "the received theory") fails utterly in the presence of this apparently recognised fact: my own suggestion on the same problem, based as it was on strong evidence, both positive and negative, not only does not fail, but actually makes the very result which seems so amazing antecedently probable. Let us consider:—

In my theory appeared three classes of bodies as parents of meteor-systems:—*First*, the earth and her fellow terrestrial planets, as the parents—when in the sunlike stage—of minor families of meteors crossing severally the tracks of their generating orbs; *secondly*, the giant planets, as the parents when in the sunlike stage, possibly even now, of meteor-systems travelling around the sun, but crossing the orbits of the giant planets from which they respectively came; *thirdly*, our sun and his fellow suns, as the parents of families of meteors which only pay occasional visits to other solar systems than those from whose ruling centre they originally proceeded. Is there no higher order of bodies which might have generated meteors travelling with the greater velocities now recognised? Undoubtedly there is a class of bodies which not only might have generated such velocities, but, if my theory of the origin of meteors is sound, might be expected to have ejected meteors with velocities of those high orders. There are the giant suns, like Sirius and his fellows, so enormously surpassing our own sun, and those among the stars which must be regarded as his fellows,

as to differ not merely in degree but in kind (just as suns differ from giant planets, these from our earth and her fellow-planets of the—so-called—terrestrial order, these from asteroids, and asteroids from meteors). Of six hundred stars examined by Secchi, one-half showed the spectrum characteristic of the giant suns, the spectrum belonging to Sirius (*known* to be a giant sun) and to all the bluish-white stars—a spectrum characterised by the great strength and breadth of the hydrogen lines. As Sirius gives out 200 times as much light as our sun, he probably has a surface 200 times as large, a diameter 14 times as large, and a volume 3,000 times as large. Assigning to him a volume only 1,000 times as large, we must regard him as belonging to a higher order among suns: and probably all the orbs which have a similar spectrum belong to the same order.

Now, if our sun can eject bodies with a velocity of 500 miles per second, as he has been observed to do, which would imply the power of ejecting bodies with such velocity that not only would they pass for ever away from him, but they would never have their velocities reduced by his retarding action below 22 miles per second, we may fairly expect that among meteors coming to the solar system from our sun's fellow-stars, would be some travelling with velocities of 20 or 30 miles per second, in addition to the velocities acquired under the sun's attractive influence while they were drawing near to him. (These added velocities, I may remark in passing, would be considerably less than those which the sun can impart to bodies approaching him under his own attractive influence only.) But among bodies ejected from the giant suns would certainly be many travelling with much greater velocities than 20 or 30 miles per second—probably many with velocities of more than 100 miles per second, even after they have passed into interstellar space. Such bodies, travelling in flights, would account perfectly for the meteor systems with persistent radiant points detected by Mr. Denning.

In other words, the conclusions which, on any other theory of the origin of meteors and comets than that which I have advanced, appeared so improbable that even the strongest evidence seemed for awhile insufficient to establish them, are found to follow so naturally from the processes which my theory indicated, that we might almost have expected them to be established by just such evidence as Mr. Denning has obtained. Only, of course, his description of these radiants as stationary, as well as his opinion as to the close approach to the determination of the radiant which he supposes himself able to make, must both be rejected.

It is interesting to note, in conclusion, that, with velocities averaging 100 miles per second, meteors would not require many thousands of years to traverse such distances as separate star from star (that is, sun from sun), instead of the period of several millions of years required for these journeys as heretofore viewed. But thousands of years are as mere seconds in cosmical astronomical time. So that star-born meteors of the orders recently recognised might fairly be described as *flitting from sun to sun.*

Letters.

The Editor does not hold himself responsible for the opinions or statements of correspondents.]

EXTRACT FROM A LETTER FROM PROFESSOR W. H. PICKERING.

. . . . I was much interested in your article on the Orion nebula, as I am preparing an article on the subject myself. I think no one can examine the photograph carefully without being struck by the similarity to some of the coronal forms. I was rather disappointed in Mr. Roberts' photographs. In detail they may be slightly better than the Harvard pictures, as his focal length is more than twice ours. But in extent they certainly do not excel, and I scarcely think equal, one of ours taken a year ago last February, with an exposure of only 90 minutes. You will find a lantern slide copy in the rooms of the Royal Astronomical Society. I notice in your article you speak of the nebula to the north of the great nebula. Our negatives show them to be connected by a nebulous mass of considerable complexity. In fact the whole sword handle is simply one great nebulous mass. I hope to have my article ready for distribution in a few weeks. . . . .

May 27, 1889. W. H. Pickering.

EXTRACT FROM A LETTER FROM PROFESSOR E. S. HOLDEN.

. . . . I am much interested in the resemblances which you point out in Mr. Roberts' wonderful photographs of the Orion nebula and the coronal forms. Mr. Roberts was kind enough to send us prints of his Andromeda nebula, but I have not seen any copy till now of the Orion nebula. It is most interesting. With the original negatives before you, you are in a position to judge of the analogies to groups of synclinal structure in the corona and in the nebula. I have looked over my own notes of the nebula (central parts only), and find nothing of importance which can strengthen your argument except perhaps the existence of cometic tails to the stars Bond 685, 708, 741, the three s.p. the trapezium. These *look* like the polar rays of the corona. . . . We expect to send a (photographic) expedition from here to South America to observe the December eclipse. I shall be very glad of any information which you can give us as to the best stations (healthiest, most convenient of access, most likely to be clear), and for any notice of the plans of other parties, so that we may co-operate with them. . . . E. S. Holden.

Lick Observatory: May 28, 1889.

To the Editor of Knowledge.

Sir,—Your article on lightning photographs has interested me greatly. Among the many ingenious suggestions which it contains, what appears to me to be a very obvious one as to the cause of the dark flash has been omitted. We know from common observation that there is blue lightning and pink lightning, and we know that the two colours act very differently on the photographic plate. I have before me a photograph of a young lady in a blue dress, wearing a red rose. The blue dress has come out absolutely white, and the pinkish rose seems nearly black upon it. May there not be the same effect with lightning?—I am, Sir, yours obediently, G. H. Clarke.

[The so-called black flash is absolutely darker than the background of sky on which it appears. The red rose or pink lightning would have a slight effect in darkening the plate, though a slower one than the blue dress or the blue lightning. We have to account for something which cuts down the light of the background on which it is seen, and not merely for a difference of rate of light action.—Editor.]

THE DARK FLASH.

To the Editor of Knowledge.

Sir,—With the June part of Knowledge there appeared facsimiles of a considerable number of lightning-flashes, many of which were very curious, and nearly all strikingly beautiful.

In plate No. 4, forming part of the frontispiece, was shown the well-known but puzzling appearance to which the rather paradoxical title of "The Dark Flash" has been given. This, it will be remembered, is a black line, similar in character to ordinary lightning-flashes, and in this case especially like those on the same plate. It has been suggested that this dark line on the plate may result, through some photographic complication, from an actual and immediate bright flash—that is, that the black line of the plate may really be a picture of a *bright* line. Professor Stokes, however, as explained in the text, is of the opinion that the dead flash is really the dark line which it appears on the photograph, and that it follows in the track of an antecedent bright flash. Steps have been proposed by which direct evidence upon this point may perhaps be obtained.

In the meantime it has been suggested (as was also set forth in KNOWLEDGE last month) that the dark line is due to absorption of light by a column of dark-coloured—to wit, reddish-yellow—gases, produced by the direct union, under the influence of electricity, of the oxygen and nitrogen in the air. It is well known to chemists that if the sparks of an induction coil be passed continuously through a vessel containing air, yellowish fumes will presently form, consisting of nitrogen trioxide (N_2O_3) and nitrogen peroxide (NO_2); and there is no doubt that the same thing occurs when a thunderstorm takes place, these gases being found dissolved in rain-water collected after thunder. Whether they are formed indirectly or directly there is not, so far as I am aware, any evidence to show. It may well be that nitrogen dioxide (N_2O_2) is first formed, and that this colourless gas subsequently absorbs additional oxygen, thus forming the familiar red fumes of the higher oxides. However this may be, it does not at present affect the question in hand, and the point need not have been raised, except that I can imagine it coming up later on, when further steps have been taken experimentally to ascertain the cause of the dark flash.

Now this experiment, though not often performed on the lecture-table, is fully set forth in all the text-books. But there is nothing, so far as I can ascertain, to show that, even in the undisturbed air of a laboratory gas-holder, the fumes exhibit any tendency to follow the line of the electric sparks. I have never been able to see that they do so, and indeed it would be a remarkable deviation from the usual behaviour of free gases if they did. Gases invariably tend to diffuse themselves, and this property would surely prevent the nitrous and nitric fumes from forming, even for a very short space of time, a line or column as narrow and as sharply defined as the dark flash is clearly shown to be. It is noteworthy that on this hypothesis the photograph of the dark flash must be impressed upon the plate some seconds at least after the flash which it belongs to.

As an alternative explanation it has been suggested that the dark track shows the smoke of burnt dust floating in the air and preserving the shape of the flash which burned it up. This is ingenious; and the dark flash in photographs certainly looks more like a truly black line than a reddish-yellow one, which would hardly be expected to produce so decided an effect. On the other hand, however, it must be remembered that the dust particles are very minute indeed; being, in fact, often invisible even with high microscope powers. Even if any smoke at all be produced, it must therefore be very small in amount, and fine in texture, which renders doubtful the possibility of photographing it. Moreover, it is probable that the extreme heat of the flash would be capable of entirely volatilising such infinitesimal matter, which would disappear instantaneously, and, like Prospero's insubstantial pageant,

"Leave not a wrack behind."

I believe, nevertheless, that the true explanation of this phenomenon is to be found in connection with the floating matter of the air. Before coming directly to the point, however, it will be necessary to work back a little.

We have all observed the stream of intangible dust which shows itself in the track of any sharply-defined sunbeam, giving the latter an almost solid appearance. It is not generally known that the path of the ray could not be traced at all if this floating matter were absent. It is the fact, however, that if the floating matter of the air be by special means removed from a room, or, more conveniently, from a glass tube, rays of light, though still passing uninterruptedly through the vacant space, can no longer be followed by the eye in their course.* Now, if from a certain portion of a beam of light the suspended solid matter of the air be artificially abstracted, that portion of the beam will appear to be traversed by a distinct black line. This circumstance was first fully explained by Professor Tyndall in his essays on "The Floating Matter of the Air." †

He writes :—"In a cylindrical beam which strongly illuminated the dust of the laboratory I placed an ignited spirit-lamp. Mingling with the flame and round its rim were seen curious wreaths of darkness, resembling an intensely black smoke. On placing the flame at some distance below the beam the same dark masses stormed upwards. They were blacker than the blackest smoke. . . ." At first he was inclined to think that the blue flame of alcohol did not, after all, represent complete combustion. "But is the blackness smoke?" he goes on to ask. "This question presented itself in a moment, and was thus answered :—A red-hot poker was placed under the beam; from it the black wreaths also ascended. . . . Smoke was therefore out of the question. What, then, was the blackness? It was simply that of stellar space—that is to say, the blackness resulting from the absence from the track of the beam of all matter competent to scatter its light. When the flame was placed below the beam, the floating matter was destroyed *in situ*, and the air, free from this matter, rose into the beam"—being forced up by the heat of the flame. A subsequent experiment in the same field bears directly on the subject of this paper. Professor Tyndall tried the effect of stretching a platinum wire, afterwards heated to redness by a current of electricity, just under the path of the beam from a powerful light. He writes—"A stream of air rose from it, which, when looked at edgeways, appeared darker and *sharper* than the blackest lines of Fraunhofer in the purified spectrum. Right and left of this dark black band the floating matter rose upwards, bounding definitely the non-luminous stream of air." ‡ Now is it not evident from this that the dark flash—so called—may well be due to the destruction of the floating dust by the ordinary flash, and the consequent inability of its track to reflect the light of a subsequent flash? The extreme sharpness of the line agrees well with Tyndall's observations, and the intensely black appearance of the smoke-effects which he mentions will account for the ease with which the dead flash is photographed, in a way which neither the nitric fume explanation nor the dust-smoke explanation will do. It is fair to remark, however, that Tyndall does not speak of the appearance of the beam *after* the platinum wire was removed;

* The electric beam is well known to bacteriologists as a test of floating matter far surpassing in delicacy the most powerful magnifying instruments. The air of a chamber is known to be completely sterilised only when it fails to reveal the track of a ray of light. To vessels in this condition Professor Tyndall applies the term "optically empty."

† *Longmans* (1881), p. 5.

‡ *Ibid.*, p. 6. The italics are mine.—T. B. R.

but any one who will take the trouble to make the experiment with a red-hot poker will be able to see that the effect persists for quite an appreciable time—certainly long enough for a flash of lightning to appear.

It should not be difficult to directly verify the theory, here advanced for (I believe) the first time. Let some one, who has the requisite appliances, so arrange the beam from an oxyhydrogen or arc lantern, that a series of sparks from a Wimshurst machine may play athwart it in a suitable atmosphere. The track left by these sparks should, if there be anything in the theory, be readily photographed.—Yours faithfully,

1 Roehampton Street, S.W. T. B. Russell.

[The objection to Mr. Russell's theory which presents itself, is that the dark flash must be seen through a great thickness of dust-laden illuminated air, and also on a background of dust-laden air equally lit up, and a small thickness of dustless air in the region of the dark flash would make no appreciable difference in the amount of light received from the direction of the flash.—Editor.]

THE VANILLA.

Of the many admirers of vanilla, and of vanilla-flavoured confectionery, but few know that it is produced from a species of orchid. This plant seems to require very little soil for its nourishment, and it generally attaches itself by means of its little aerial rootlets to walls, trees, and other suitable objects. It has a somewhat long and fleshy stem, and the leaves are alternate, oval, and lanceolate (shaped like a lance). The flower is of a greenish white, and forms axillary spikes. The fruit, which is a pod, when full grown measures from ten to twelve inches, and is about half an inch in diameter. The commercial vanilla (from the Spanish, *vainilla*, diminutive of *vaina*, a pod) is generally produced from the plant *Vanilla planifolia* (Andrews), a native of Eastern Mexico. It is also extensively cultivated in Réunion, the Seychelles, and Java, but the Mexican vanilla is thought to be the best. The quality of a vanilla pod can always be determined by the presence or the non-presence of a crystalline efflorescence called *givre*, and also by the colour of the pod, which in the best varieties is of a dark chocolate brown. But it is the crystalline efflorescence which contains the substance to which the fragrance of vanilla is due. This substance is called *vanillin*, and is chemically known by the formula $C_8H_8O_3$. The pods contain also vanilla acid, oily matter, soft resin, sugar, gum, and oxalate of lime. The choleraic effects that sometimes occur through eating ices flavoured with vanilla may not be due to the vanilla, but to putrefactive changes in the milk; but it is known that the vanilla plantations are subject to the attack of a little pest known as *Bacterium putredinis*, and it is quite likely that the poisonous effects from ice-eating can be accounted for by the presence of some microscopic fungi in the vanilla.

In the plantations the vanilla plant is generally fertilised by hand, but, like other orchids, there is no doubt its fertilisation is promoted by insects when in its natural state. The wild plant yields a smaller fruit, and is distinguished in Mexico as *Baynilla cimarona*, while the cultivated vanilla they call *Baynilla corriente*. A. J. F.

REFRACTION OF MAGNETIC RADIATION.

As the readers of Knowledge are aware, Dr. Hertz has made us familiar with the phenomena of reflection and interference of ether waves due to electro-magnetic radiation. By means of a prism of pitch, he has more recently obtained an experimental proof of their obedience to the laws of refraction. Professor Oliver Lodge has now gone a step further. In a paper read before the Physical Society he described a series of experiments he had carried out in conjunction with Dr. J. L. Howard, in which they had employed a pair of plano-convex hemi-cylindrical lenses, made of the best commercial pitch. With these lenses they performed such experiments as would be made with a beam of light and similar lenses of glass. We may mention that the lenses were 85 centimetres high, 90 centimetres broad, and 21 centimetres thick. The weight of them being about 3 cwt. each. Dr. Lodge found that the results obtained with them were throughout in complete agreement with those of Professor Hertz.

The *Magic Lantern Journal* is the title of a new monthly which has been sent us. The existence of such a periodical may be taken as evidence that there is some one who believes there is a large class interested in the illustration of lectures. We greatly welcome the growing tendency to illustrate lectures by photographs thrown on the screen. If the photographs are untouched, such illustrations bring the audience more directly into contact with the thing to be studied than any hand-drawn pictures.

The total length of the submarine cables at present in use is given by an Austrian paper at 113,031 miles. Of this length 102,531 miles belong to various companies, and 10,500 are Government property.—*Electrical Review.*

THE FACE OF THE SKY FOR JULY.

By Herbert Sadler, F.R.A.S.

There is still a marked absence of spots of any size on the sun's surface. During the first three weeks of July there will be no real night in any part of the British Islands. Minima of the Algol-type variable δ Libræ (cf. "Face of the Sky" for April) occur on the 1st at 8h. 24m. p.m. on the 8th at 7h. 58m. p.m., on the 14th at 7h. 32m. p.m. on the 22nd at 7h. 6m. p.m., and on the 28th at 6h. 40m. p.m. Mercury is a morning star throughout July, and is well placed for observation during the second and third weeks of the month. He is at his greatest western elongation on the 12th (20° 37′ W.), when he rises at 2h. 40m. a.m. or 1h. 20m. before sunrise, with a northern declination of $20\frac{3}{4}$°, He appears then as a half moon with an apparent diameter of $7\frac{1}{2}''$. On the 20th he rises at 2h. 43m. a.m., or 1h. 26m. before the sun. At 3h. a.m., on the morning of the 9th, Mercury will be about 18′ *n.p.* the $4\frac{1}{2}$ magnitude star χ' Orionis. During this month he passes from Orion through Gemini into Cancer. Venus is a morning star, and is at her greatest elongation ($45\frac{1}{2}$°) west on the morning of the 10th, when she appears as a half-moon with an apparent diameter of 24″. She rises on the 1st of the month at 1h. 28m. a.m., having an apparent diameter of $25\frac{1}{2}''$, and a northern declination of $15\frac{3}{4}$°. On the 31st she rises at 1h. 0m. a.m., having then an apparent diameter of 19″ and a northern declination of $20\frac{3}{4}$°. Throughout July she is in the constellation Taurus; passing through the northern portion of the Hyades about the middle of the month. On the morning of the 13th Venus will be about 40′ *n p.* the 4th magnitude star δ Tauri, the planet and star forming a

pretty naked-eye pair; on the morning of the 14th she will be about 25′ *n.f.* the $4\frac{1}{2}$ magnitude star 68 Tauri, and on the morning of the 23rd she will be 30′ north of the $5\frac{1}{2}$ magnitude star 106 Tauri, and 8′ *n.p.* the $6\frac{1}{2}$ magnitude star 107 Tauri. Mars is invisible. Jupiter, owing to his great southern declination, is very badly placed for the observer. He rises on the 1st at 7h. 35m. P.M., having a southern declination of $23\frac{1}{4}$°, and an apparent diameter of 46″, and on the last day of the month at 5h. 25m. P.M., his southern declination having increased by 6′, and his diameter decreased to $44\frac{1}{2}$″. He describes a short retrograde path in Sagittarius, and on the night of the 13th will be 24′ south of and a little *p* the $5\frac{1}{2}$ magnitude star Piazzi xvii. 386. He will be not far from the moon on the evening of the 11th. The following phenomena of the satellites occur between the times of the planet's being 8° above the horizon and the sun's being 8° below, and midnight G.M.T. on the days named. At 10h. 22m. P.M. on the 6th, an occultation (disappearance) of the first satellite. On the 7th at 9h. 45m. P.M. an egress from transit of the first satellite, and at 10h. 5m. P.M. the egress of its shadow. At 11h. 37m. P.M. on the 9th an occultation (disappearance) of the second satellite. At 9h. 20m. P.M. on the 11th an egress from transit of the second satellite, and at 10h. 10m. P.M. the egress of its shadow. At 9h. 42m. P.M. on the 14th a transit ingress of the shadow of the first satellite (the satellite itself being already on the disc of the planet), at 11h. 30m. P.M. the egress from transit of the satellite itself, and at 11h. 59m. P.M. the egress of the shadow. On the 15th at 9h. 17m. 28s. P.M. a reappearance from eclipse of the first satellite. At 11h. 30m. P.M. on the 17th an occultation (disappearance) of the third satellite. At 10h. 6m. P.M. on the 18th a transit ingress of the shadow of the second satellite, and at 11h. 37m. P.M. an egress of the satellite itself. On the 21st at 10h. 59m. P.M. a transit ingress of the first satellite, and at 11h. 37m. P.M. a transit ingress of its shadow. On the 22nd at 11h. 12m. 11s. a reappearance from eclipse of the first satellite. At 11h. 30m. P.M. on the 24th a transit ingress of the shadow of the fourth satellite. At 11h. 15m. P.M. on the 25th a transit ingress of the second satellite. At 9h. 29m. 56s. on the 27th a reappearance from eclipse of the second satellite. At 10h. 30m. P.M. on the 28th an egress from transit of the shadow of the third satellite. On the 29th at 10h. 4m. P.M. an occultation (disappearance) of the first satellite. At 9h. 28m. P.M. on the 30th an egress from transit of the first satellite, and at 10h. 18m. P.M. an egress of its shadow. Saturn may be caught low down on the western horizon during the first fortnight of the month; after that he will be too near the sun to be visible. On the first he sets at 10h. 16m. P.M., and on the 14th at 9h. 29m. P.M. He describes a short direct path in Leo, but does not approach any naked-eye star very closely. Uranus is in Virgo, and sets on the 1st at 11h. 59m. P.M., and on the 31st at 10h. 1m. P.M. He describes a short path to the S.E. between θ Virginis and Spica. Neptune is invisible. Shooting stars are fairly numerous in July, though the twilight interferes with observation. A well-marked shower radiates from near δ Aquarii; the maximum being on the 28th. The radiant point is in 22h. 40m. −13°. The moon enters her first quarter at 5h. 59m. A.M. on the morning of the 6th, is full at 9h. 2m. P.M. on the evening of the 12th, enters her last quarter at 7h. 45m. P.M. on the afternoon of the 19th, and is new at midnight on the 27th. There will be a partial eclipse of the moon on the evening of the 12th, which will be partly visible at Greenwich, slightly less than half the lunar disc being observed at the greatest phase. The first contact with the shadow takes place at 7h. 43·1m. P.M., at an angle of 39° from the north point of the moon's limit towards the east, the moon rising at Greenwich at 8h. 14m. The middle of the eclipse is at 8h. 54m. P.M., when 0·48 of the lunar surface will be obscured. The last contact with the umbra takes place at 10h. 4·9m., at an angle of 45° from the north point towards the west. These angles are for direct image. The last contact with the penumbra takes place at 11h. $12\frac{1}{2}$m. P.M. On the 6th at 8h. 5m. P.M. the 6th magnitude star 80 Virginis will disappear at an angle of 56° from the vertex, and reappear at an angle of 290° at 9h. 12m. P.M. The 6th magnitude star o^2 Libræ will disappear at 7h. 48m. P.M. on the 8th at an angle of 75° from the vertex, and reappear at 8h. 59m. P.M. at an angle of 240° from the vertex. The 6th magnitude star B.A.C. 6343 will disappear at 11h. 43m. P.M. on the 11th, at an angle of 137° from the vertex, and reappear at 0h. 36m. A.M. on the 12th at an angle of 239° from the vertex. At 1h. 16m. A.M. on the 12th the 6th magnitude star 26 Sagittarii will disappear at an angle of 77° from the vertex, and reappear at 2h. 11m. A.M., at an angle of 333° from the vertex. At 7h. 22m. P.M. on the same day the $6\frac{1}{2}$ magnitude (it is really fainter) star B.A.C. 6699 will disappear at an angle of 47° from the vertex, but the star is below the horizon at the time, the moon not rising at Greenwich till 8h. 14m. P.M.; it will reappear at 8h. 23m. P.M., at an angle of 241°. At 9h. 12m. the 6th magnitude star 53 Sagittarii will disappear at an angle of 37° from the vertex, and seven minutes later the $6\frac{1}{2}$ magnitude star B.A.C. 6727 will disappear at an angle of 38° from the vertex—these two stars form a single star to the naked eye—53 Sagittarii reappearing at 10h. 12m. P.M., at an angle of 279° from the vertex, and B.A.C. 6727 9 minutes later, at an angle of 282° from the vertex. These three occultations take place during the partial eclipse, but in all three cases the disappearances and reappearances will take place at points of the lunar disc unobscured by the shadow of the earth. At 10h. 8m. P.M. on the 13th the 6th magnitude star 17 Capricorni will disappear at an angle of 14° from the vertex, and reappear at 10h. 46m. P.M., at an angle of 312° from the vertex.

ERRATUM.—On page 172 of KNOWLEDGE for June, second column, line nineteen, *for* 0″ 07 *read* 0″ 046.

A part of vol. xlix. of the "Memoirs" of the Royal Astronomical Society has just been issued, containing a paper by Mr. N. E. Green, "On the Belts and Markings of Jupiter." It is illustrated by twenty-one chromo-lithographic drawings of the planet. Mr. Green's great artistic skill enables him to represent the soft-edged cloud-like markings and the curious gradations of colour on the planet better than most other observers, and probably one would be correct in saying better than any other observer. The drawings on stone for the chromo-lithographs have all been made by Mr. Green.

Chess Column.

[Our Chess column has been placed in the hands of Mr. R. F. Fenton during the absence of Mr. Gunsberg, who has gone to play at the International Chess Tournament in New York. Mr. Gunsberg has now returned, but was not in time to undertake the preparation of this article.—EDITOR.]

THE NEW YORK INTERNATIONAL TOURNAMENT.

The tie between Max Weiss, the Vienna champion, and Michael Tchigorin, the Russian champion, has been played off, with the disappointing result that four games having been played, all ending in draws, the combatants have, in accordance with the rules of the tournament, equally divided the first and second prizes, of the respective values of 200*l.* and 150*l.* As in consequence of this lame and impotent conclusion there is no actual winner of the tourna-

ment, we presume the contemplated match for the championship of the world has fallen through. It must be allowed, however, that the literature of the game has been enriched by some splendid examples of play on the part of the European masters. We append a lively skirmish played between Messrs. Bird and Burn in the late tournament, together with two remarkably fine endings of games contested at the same gathering:—

KNIGHT'S GAME OF RUY LOPEZ.

WHITE. H. E. Bird.	BLACK. A. Burn.	WHITE. H. E. Bird.	BLACK. A. Burn.
1. P to K4	P to K4	12. Kt to Kt3	Kt to Q5 (*c*)
2. Kt to KB3	Kt to QB3	13. P × Kt	B × B
3. B to Kt5	Kt to B3	14. Q to Q2 (*d*)	P × KP
4. Q to K2 (*a*)	P to Q3	15. P × P (at K4)	P × P
5. P to B3	B to Q2	16. Kt × P	QR to Qsq
6. P to Q3	P to KKt3 (*b*)	17. Q to B2	Kt × P
7. QKt to Q2	B to Kt2	18. Kt × Kt	B × Kt
8. Kt to Bsq	Castles	19. B × P (*e*)	KR to Qsq
9. B to Kt5	P to KR3	20. P to B3	Q to R5 (ch)
10. B to K3	Q to K2	21. P to KKt3	Q × B
11. P to KR3	P to Q4	Resigns.	

NOTES.

(*a*) The best move here has long been the subject of controversy. Castling has been more generally adopted in the present tournament, but P to Q4 found many advocates.

(*b*) A favourite development with Mr. Burn.

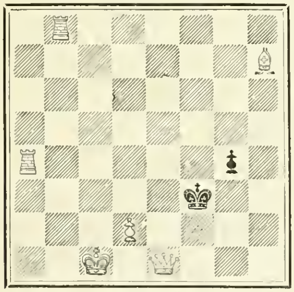
(*c*) Very ingenious, and the turning-point of the game.

(*d*) Q to QB2 would have been a better move; Mr. Burn takes instant advantage of the Queen's present bad position.

(*e*) In such a position it matters little what move is made, the game is hopeless.

PROBLEM BY HERR CAPRAETZ.

BLACK.



WHITE.

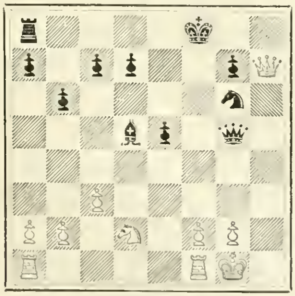
White to play and mate in two moves.

White, six pieces; Black, two pieces.

Position after Black's eighteenth move, in a game played at the tournament, Pollock *v.* Gunsberg. The former had the move, Mr. Gunsberg defending with the Fianchetto di Donna.

J. GUNSBERG.

BLACK.



WHITE.

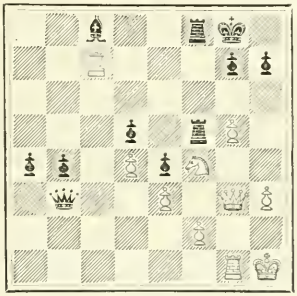
W. H. POLLOCK.

WHITE.	BLACK.
19. P to KKt3	K to B2
20. Q to R3	R to Rsq.
21. P to KB4	Kt × P
22. R × Kt (ch)	P × R
23. Q × P (ch)	K to Kt3.
24. Kt to K4	P × P
25. R to Ksq.	Q to R5
26. Kt to B2	Q to R8 (ch)
27. Kt × Q	R × Kt mate.

Position after Black's thirty-first move in one of the tourney games, Blackburne *v.* Lipschutz. The opening was the Queen's gambit, declined.

S. LIPSCHUTZ.

BLACK.



WHITE.

J. H. BLACKBURNE.

WHITE.	BLACK.
32. P to Kt6	P to R3
33. R × P (ch)	K × R
34. Kt to R5 (ch)	R × Kt
35. Q to B7 (ch)	K to B3
36. Q to Q6 (ch) and mates in 3 moves	

The match between Mr. Loman, Champion of Holland, and Mr T. Block, at the City of London Chess Club, is practically over. There is still an end-game pending, which is almost certain to end in a draw, leaving Mr. Block the winner of the match by 4 games to 2 games.

In the Spring Tournament at the same club, Mr. Woon has been declared the victor of No. 3 section, closely followed by Mr. E. O. Jones.

The competition for the special prizes presented by Messrs. Mocatta and Anger is still in progress, and Mr. E. O. Jones, Mr. Anger, and Mr. Hunt are abreast.

At the British Chess Club a match has lately been played between Mr. Wainwright and Mr. Ingoldsby of five games up, draws not to count. Mr. Wainwright drew the first game, and then won four in succession. Mr. Ingoldsby then resigned the match.

The sixth Congress of the German Chess Association commences on the 15th inst. The Masters' Tournament will probably last a fortnight. There are five prizes announced, viz.:—First prize, 50*l.*; second, 35*l.*; third, 25*l.*; fourth, 15*l.*; and fifth, 7*l.* 10*s.*

The Amsterdam Tournament, commencing on August 25, offers three prizes of the value of 33*l.* 10*s.*, 18*l.* 15*s.*, and 10*l.* 5*s.* It is hoped that a Chess Tournament will be arranged, to take place in Paris some time in August. An influential committee has been formed, and the prizes proposed are—first prize, 2,500 fr.; second, 1,000 fr.; third, 800 fr.; fourth, 600 fr.; fifth, 400 fr.; sixth, 200 fr. It is expected that the full programme will be soon issued.

ANSWERS TO CORRESPONDENTS.

Correct solutions to problem in our last number by E. W. Tarn, S. Anstey, J. Jenkins, and F. Gibbs.

W. HILLIER.—An excellent work on the openings is "Chess Openings," by E. Freeborough and the Rev. C. E. Ranken; Trübner & Co., London. Write to Mr. W. W. Morgan, Chess Publisher, 17 Medina Road, Upper Holloway, N., who has also just published an excellent collection of games from the New York Chess Congress, price one shilling.

Whist Column.

By W. MONTAGU GATTIE.

AMERICAN LEADS.

(*Continued from page* 175.)

We have already hinted that the system of leads which we described in the May number of KNOWLEDGE has been the subject of considerable controversy in whist circles. To many players, and particularly, no doubt, to those of mathematical tastes, there is something very attractive in the establishment of a code which marshals in scientific order and invests with a uniform meaning the various conventions as to leading from long suits that have, one by one, grown gradually into use, as experience in actual play has suggested them. Thus, in the last edition of "Cavendish," we find the author enthusiastically remarking:—"The more the American system is examined, the more thorough and perfect it will be found."

On the other hand, the system is objected to by some strong players, partly on the ground that it adds to the technicalities of the game, and so increases the difficulties of beginners, but more especially because they oppose on principle the growing tendency to formulate exact methods of play, urging with some force that the undue multiplication of such formulæ is apt to crush the life out of a game which, after all, depends on powers of ready inference and adroit strategy rather than on the rigorous observance of definite laws.

As regards the first objection, we have already said that the student may very well acquire sufficient knowledge of whist to enable him to play an intelligent rubber without troubling himself at all with American leads; and he would, in our opinion, do wisely to reserve their consideration until he has thoroughly grasped the main principles of the game. But to these who have already become fairly proficient, and whose faculty of observation is sufficiently trained for them to derive benefit from penultimate and antepenultimate leads and other recognised openings from suits of five or more cards, the new code is, as we believe, of great service, not only because it systematises, as already explained, the existing conventions, but also because it affords in many cases an easy means of obtaining information which would otherwise be beyond the reach of any but the finest players.

For example, A leads, as his original lead, the 7 of spades; Y follows with the 4; B (A's partner), holding queen knave only, plays knave; and Z plays 8. B can at once place king, 10, 9, of spades in A's hand, unless both the adversaries are calling for trumps. For, except in that case, A must have either deuce or trey of spades, and therefore has led from a suit of five cards at least, so that he does not hold the ace; and, as he must have three cards higher than the 7, they must be king, 10, 9. Hence it follows that Z is either asking for trumps or void of spades, and that Y has the ace. Now let us suppose that from a suit consisting of king, 10, 9, 7, 3, 2, A had led the lowest instead of the fourth best. It is clear that B would have been able to gather none of the valuable information we have mentioned; and, although he might by carefully observing the fall of the cards have arrived ultimately at the same conclusions, he could not have done so nearly as easily or as certainly as if A had followed the American rule.

To take one other instance. From king, queen, 8, 6, 4, A leads king, Y plays 7, B (holding ace, 9, 3) puts on the 3, and Z plays 2. A continues with the 6, Y plays 10, B plays ace, and Z plays 5. The queen of course would have been marked in A's hand whether he had led the 6 or the 4; but, by continuing with the original fourth-best, he shows B in addition (1) that he has the 4 (for no one else can hold it), and therefore that his suit consisted of five cards, and (2) that his other high card is the 8, for he must have two cards higher than the 6, one of them is the queen, and the other, since A has continued the suit with a small card, cannot be the knave, and must therefore be the 8.

The second of the arguments to which we have referred has much more weight. It is contended that the necessity of conforming to a stringent system of conventions tends to deaden the imagination, and furthermore to limit the scope for strategy and artifice. It must be conceded that the appearance of one or two false cards in the course of a hand may seriously interfere with the calculations of a player who always proceeds on strictly scientific principles; while, on the other hand, the man who is too intent on watching for refinements of leads is liable to overlook opportunities for a bold stroke or a successful ruse.

Not very long ago the writer was triumphantly assured by a gentleman who has probably played as many rubbers as any man living, and who is well versed in all that "the books" can teach, that playing whist occasioned him no mental effort whatever, but was to him "mechanical, purely mechanical." Those who are acquainted with this gentleman's style of play would scarcely be prepared to combat his assertion; and we fear that there are other practised players who regard the conventions of whist as the highest poetry of the game instead of being merely its alphabet. Indeed, it may be questioned whether the habit of playing according to rule does not tend to produce even in the best players some degree of insensibility to occasions when the rule may be departed from with advantage.

Thus, in the domain of whist, as in that of chess, we have an old and a modern school, the one relying mainly on strategy and ready wit, while the other aims at greater scientific accuracy, or, as some critics irreverently call it, "pip-counting." But it must not be forgotten that the objections which we have pointed out would, if pushed to their logical conclusion, assail the whole of the beautiful system of conventions which has raised whist to its present unique position among games of chance. The player with a talent for strategy will always stand on a higher level than the man who has no idea beyond dull conformity with routine; but strategy must have some facts to go upon, and for these it must look to "pip-counting."

Some of the leading opponents of the American code are men who can generally reckon on discovering for themselves in the course of the play nearly all that American leads can tell them; and they may not unnaturally view "with scornful, yet with jealous eyes," the invention of simpler means of information. It is probable that the "developments" introduced by the modern school are more useful to an indifferent player than to a good one; but the same thing may be asserted of other conventions now generally accepted, and notably of the call for trumps. Before the institution of the call, every one had to decide for himself whether a trump lead would be likely to suit his partner's hand, and players with a genius for the game had a marked advantage in this respect; whereas nowadays the information is generally open to any one who takes the trouble to observe what cards his partner plays. And, after all, seeing how much every whist-player is doomed to suffer from the shortcomings of an obtuse partner, is there any need to decry methods by which people who would otherwise play very badly are enabled to play tolerably well? Nor do we think that the good players have anything to fear from this levelling up, or that the game itself has anything to lose by being reduced to scientific principles. Opportunities for deep combinations, for brilliant strokes of play, can scarcely be diminished, even if they be not increased, by more precise indications as to the position of the cards, and the best players must inevitably come to the top, as heretofore. As already observed, it often becomes a question whether it is preferable to declare strength in a suit or to conceal it; and, while the necessity of deciding in certain cases whether to adopt or to avoid an American lead affords fresh scope for the exercise of judgment, we must depend on intuitive quickness of perception to determine whether the card actually led under such circumstances by partner or opponent is to be trusted or suspected.

In our next article we shall give a hand illustrating the American system of leads, and we shall conclude our review with some observations as to the management of trumps.

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Scars and markings on a man struck by Lightning at Hampstead, on June 14th, 1888.

Lightning at Hampstead, on 14th June, 1888.

Taken at Cambridge on 6th June, 1889, by the Rev. A. Rose, of Emmanuel College.

Poplar Struck by Lightning in Regent's Park, on 6th July, 1881.

Oak shattered by Lightning at East Tisted,

Shoes worn by children when struck by Lightning in Atcham Church, Shrewsbury, July, 1879.

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AN ILLUSTRATED
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LONDON: AUGUST 1, 1889.

CONTENTS.

MORTALITY AND ACCIDENTS FROM LIGHTNING.

By W. Marriott, *Secretary of the Royal Meteorological Society.*

THERE seems to be an undue dread of the danger of lightning. Many people are during a thunderstorm seized with a sense of terror which upsets their nervous system, and brings on headache and other physical ills that are usually referred to the electrical condition of the atmosphere, instead of to their own mental condition. When we come, however, carefully to inquire into the number of deaths caused by lightning, it is a matter of surprise and comfort that the mortality is so small.

In a paper recently communicated to the Royal Meteorological Society by Inspector-General Lawson, it was shown that the total number of deaths caused by lightning in England and Wales during the twenty-nine years—1852 to 1880—as recorded in the returns of the Registrar-General, was 546, the yearly average being 19. The average annual rate in a million persons is 0·879. Thunderstorms are more frequent and violent in some years than in others, and consequently the numbers of deaths by lightning fluctuate considerably. For instance, there were only 3 deaths in 1863, and 6 in 1864, while there were 45 in 1852 and 46 in 1872.

In other countries the number of persons killed by lightning is much greater than in England. Colonel Parnell, in his book, "The Action of Lightning," gives accounts of accidents in various parts of the world, from which we may form an approximate idea of the relative proportion of deaths in some of the European countries. Thus, in Russia (not including Poland and Finland) there were 2,270 persons killed by lightning in the five years, 1870–74, the yearly average being 454, or 5·22 per million; in Prussia there were 1,004 persons killed in the nine years 1869–77, the yearly average being 112, or 4·15 per million; in France there were 1,308 persons killed in the eighteen years, 1835–52, the yearly average being 73, or 1·93 per million; in Switzerland there were 33 persons killed in the two years, 1876–77, the yearly average being 17, or 5·92 per million; and in Sweden there were 664 persons killed during the sixty-two years, 1816–77, the yearly average being 11, or 2·37 per million.

The mortality from lightning is much greater among the inhabitants of rural districts than those of towns. There can be no doubt that the lightning conductors attached to churches, &c., as well as the various large buildings, serve to silently diffuse the electricity, and so deaths from lightning strokes are rarer in towns than in the open country. The recently-erected Eiffel Tower is reported to have a very modifying effect on a thunderstorm, as it forms a perfect lightning conductor. On one occasion, when a very black thundercloud, from which lightning was being emitted, passed over Paris, the lightning ceased as soon as it came within the influence of the Tower, whilst it appeared again when the cloud passed onwards.

The returns of the Registrar-General show that the mortality from lightning is greater amongst men than amongst women, the deaths of males being 81 per cent. and of females only 19 per cent. This great excess of deaths of males is no doubt due to the fact that men are more engaged in field labour and outdoor occupations, and are consequently more exposed to the dangers of thunderstorms than women. The greatest number of deaths among males occurs between the ages of 15 and 25.

The effect of lightning is not always the same; some persons are killed instantaneously and their bodies marked in a curious manner, others are rendered unconscious, and perhaps lose the use of their limbs or faculties for a time or permanently. Frequently when persons are struck their clothes are completely stripped off their bodies and hurled a considerable distance away. At the Royal Meteorological Society's Exhibition in March 1888 the clothes of a man who had been struck by lightning were exhibited; these had been blown off his body, and were almost in ribbons. His boots were burst out, and his watch partly fused. The man was not killed, but recovered after being in the hospital for some weeks.

On June 14, 1888, a slight thunderstorm passed over the north of London, when two men were struck by lightning at the Spaniard's Farm, Hampstead Heath. They were eating their dinner under a tree when the occurrence took place. One of them was rendered quite senseless, and appeared as though he were dead. The other heard a tremendous thunderclap, and was quite stunned for some minutes, but felt no pain. He then found that his trousers were smouldering, that his knife had been knocked out of his hand, and that his steel buckles had been torn off his legs. He succeeded in quenching the fire in his trousers, and managed to crawl to the road, shouting for assistance. After a time they were both conveyed to the infirmary. Their features were ghastly blue, with a dull yellowish white showing through the leaden colour. The elder one was almost pulseless, but after a time became slightly conscious. He had burns on his right side from the shoulder to the feet. Photograph 1 shows the appearance of the scars and markings on his arms and back a month after the accident. I had an opportunity of examining and photographing the clothes worn by these men. These are shown in Photograph 2.

An interesting case of the disruptive force of lightning is exhibited in Photograph 6, which is a reproduction of a photo-

graph of the boots worn by some children who were struck by lightning in Atcham Church, near Shrewsbury, in July, 1879. Sometimes the body of a person struck by lightning has markings on it of an arborescent or tree-like character. A very interesting photograph of such markings on the arm of a boy who was struck by lightning at Duns, Berwickshire, was obtained in June 1883. The boy, who was thirteen years of age, had sought shelter with three other boys in a stable when the occurrence took place; he was thrown to the ground and hurt about the face and forehead by the fall. His father, who is a chemist, writes:—

"The motion of the arms was for some while completely paralysed, inasmuch as he was unable until some considerable time after regaining consciousness to remove his hands from his pockets, where he had placed them before the accident. There was also in the arms a sensation of numbness and cold, and he fancied that they had been broken at the elbows. Other voluntary movements were at first inaccurate and unsteady. Later, upon his complaining of a burning heat in the arms his coat was removed, and markings of an arborescent character were discovered stretching from below the left elbow to the shoulder, and throwing branches of a less complicated character across the left chest. The marks were of a ramified, tree-like form, and seemed to radiate from two centres, as if the lightning had first struck the arm in two places, and had thence broken over the surrounding skin. Shortly after the accident the boy walked home without assistance, and on his arrival the marks were subjected to a closer inspection. They proved of a red colour, somewhat similar in shade to that of the spots of measles or scarlet fever. The surface of the skin was slightly raised over them, and the superficial heat of the injured arm was greater than that of the rest of the body. For two hours after the stroke they retained their original appearance, remaining to the naked eye at least perfectly unaltered. By 7.30 P.M., eight and a half hours after the accident, they were hardly visible, and at ten o'clock next morning had entirely disappeared."

Animals are much more frequently struck by lightning than human beings, probably from being more exposed to the storm, and also from taking shelter under trees, which are sometimes struck. Animals are, no doubt, quite as much terrified, if not more so, than human beings during a thunderstorm, and consequently huddle together. The heated moist air rising from their bodies forms a ready path for the lightning discharge, and consequently we frequently hear of two or more animals being killed by the same flash.

The vagaries of lightning are very strange. Sometimes one sheep only in a flock is killed, the others being untouched, or two horses may be standing side by side, when one is struck and the other uninjured. Colonel Parnell quotes a case in which sixteen natives and five oxen were killed at one discharge on the high road in Natal in 1878. A diver under water in Cole Harbour, Halifax, N.S., was rendered insensible, the air-pump having been struck by lightning. Coal mines are not apparently exempt from lightning discharges, as there is evidence to show that on July 12, 1880, lightning actually entered the workings of the Tanfield Moor Colliery.

When the lightning strikes sand it sometimes fuses it and forms what is called a "fulgurite," which is a kind of vitrified hollow tube. Some of these tubes have been found 30 or 40 feet long. Two interesting specimens of fulgurites are to be seen in the British Museum.

Trees are perhaps the objects most frequently struck by lightning. In some instances the bark only is torn off, while in others a large limb or the trunk of the tree itself is completely shattered. The shivering of the trees into small splinters is probably due to the sudden heating of the sap, which is driven into steam; the wood is consequently blown to pieces. Photographs 4 and 5 are reproductions of photographs of some trees which have been struck by lightning.

ON THE DISRUPTIVE EFFECTS OF LIGHTNING, AND ON DARK FLASHES.

By A. C. Ranyard.

We are indebted to the kindness of Mr. G. J. Symons for the loan of the two photographs of lightning-struck trees and of the burst boots worn by children in Atcham Church when it was struck by lightning ten years ago. Mr. Symons has during the last twenty years made a large collection of photographs of objects shattered and torn by lightning, and we hope that we shall at some future time be permitted to draw still further on his interesting store for the benefit of the readers of Knowledge.

Frequently only a narrow strip of bark is blown from the side of a lightning-blasted tree. The strip of bark often remains attached by its upper end, like the great splinter in our picture of the poplar in Regent's Park. It must not be assumed too readily from such an appearance that the explosion took place at an appreciably earlier instant at the lower part of the tree than in the part above, indicating, as has often been assumed, that the flash was an upward one. It is possible that the direction of the splinters only indicates that the explosive forces acted with greater energy below than above. When we consider the velocity of the current as compared with the time which would be occupied in tearing elastic splinters of wood, this seems to be the more probable explanation.

When the bark is only blown away, the shining surface of the *cambium* layer or outer ring of growing cells just below the bark is left exposed; this is the region where there is most sap, and it is generally assumed that the explosion is caused by the moisture of the growing cells being suddenly converted into steam. But the cells of the cambium layer do not generally appear to be charred, or as if they had been exposed to such heat as would instantaneously drive fluids into vapour. The explosive force also acts occasionally evidently with great energy in the central parts of the trunk where there are no growing cells. The great oak at East Tisted, shown in the lower picture, is an excellent example of this. The clergyman standing beneath it is the Rev. Wm. Howlett, known to readers of Knowledge by his admirable drawings of sun-spots. He serves us here as a standard of comparison by which the size of the great oak may be more readily realised.

The vapour-explosion theory will evidently not account for all the disruption which takes place along the line of discharge; frequently lightning shatters stone and sometimes glass, within which there can be no moisture to explode. We know that a sudden local change of temperature will shatter stones sometimes with great violence, producing noises which in the case of meteorites are probably heard over greater areas than any of the artificial explosions produced by modern artillery; but mere expansion due to the sudden development of heat will not account for the shreds into which the clothes of the lightning-struck sawyer referred to by Mr. Marriott have been torn. The clothes are not charred or singed, except in places, although the bodies of the unfortunate men were badly scorched. In the *British Medical Journal* for August 4, 1888, one of these sawyers is described as having "burns on the right side from his shoulder to his feet, bearing the appearance of

abrasions. The whole of this side (presumably the side on which he was leaning against the tree) had exactly the appearance of an exaggerated example of *post-mortem* staining; the other sawyer had his legs burnt in places from the point where he had been resting his knife downwards. The legs were cut probably by the steel buckles he had worn. . . . Both men were so scorched that no lines were visible to indicate the course taken by the electric current, although these subsequently came out as shown in the illustration."

It is evident from this description that the skin of the men must have been subjected to great heat as well as to pressure, which caused the abrasions and the bruising. The fact that the injury done was chiefly to the skin and surface tissues shows that the seat of the explosion was on the surface of the body. The current seems to have travelled along the damp surface of the skin and to have driven the moisture into vapour, which blew the clothes outward in rags without singeing them.

It is a curious fact that the boots of lightning-struck persons are nearly always burst open. The sawyers' boots, with torn "uppers," may be seen on the top of the small barrel in Mr. Marriott's photograph, and the children's boots show evidence of a disruptive force upwards, not in the direct line of discharge to or from the earth and the child. This is what might be expected on the theory that the explosion is due to moisture on the skin, which is driven into vapour. The leather of the boot would confine the perspiration, and the weakest part of the boot would go. We shall probably learn more as to the action of the electric current in producing death when the American electric methods of execution have been in use for some little time. From the facts before us at present it would seem as if a dry-skinned criminal would suffer differently from one who had struggled on his way to the scaffold and was perspiring freely.

The very interesting photograph of lightning in the lower left-hand corner of the plate was taken by the Rev. A. Rose, at Emmanuel College, Cambridge, on the evening of June 6 last. It shows the main flash bright, with dark branches spreading away from it on either side. In all other photographs of branching flashes the main flash has been brighter than the branches; we may, therefore, probably assume that in this instance the main flash was the brightest, and that the fainter flashes are reversed, while the brighter flash is not reversed. On looking more closely into the photograph, one sees that the main flash is bordered along its edges by a dark fringe corresponding to the hazy edge of the image of a bright object, described in the last number of KNOWLEDGE as due to the optical imperfections of the instrument with which the photograph was taken. This dark border to the main flash can just be seen on the photographic copy published with this. It will also be noticed that the brighter parts of some of the branches, notably the middle one on the left-hand side, are only partly reversed. In the glass transparency which I have before me, one can see that a narrow line of light runs down the central part of the branch near to where it joins the main flash. Evidently the brighter parts of the flash have given rise to bright images, and the less bright parts have reversed the photographic action produced by the background of sky, and have given rise to an area on the photographic plate which is darker than the surrounding area of sky. Taken in conjunction with the experiments described by Mr. Clayden in his letters, and with the older experiments on the reversing action of the less refrangible rays, referred to in the letter of Sir G. G. Stokes, we seem to have material here for a very interesting research. The background of sky was lit up by summer twilight rich in long wave-lengths, the blue end of the spectrum having been sieved out by the long passage of the solar light through the lower air. The light of the lightning, richer in short wave-lengths, seems to have first bleached or reversed the photographic action of the reddish light of the sky, and then to have produced its own positive effect. If this theory is correct, how is it that this particular photograph of a branching flash is the only one which shows the branches and fainter parts of the flash reversed? Possibly this photograph was taken on a background of clear sky, while other flashes have been photographed on a background of cloud. We need further observations. In experimenting, one is generally on the verge of discovery when one comes to something one does not understand. Here there is a great deal which needs explanation. If the reversing effect of one region of the spectrum with respect to another is proved, more rapid photographic action may possibly be obtained by eliminating the reversing wave-lengths by passing the light which is to form the image to be photographed through a coloured medium, which will sieve out the reversing rays.

THE COMMON COCKROACH.—I.

By E. A. Butler.

UNDER this name some may perhaps hardly recognise the insect so well known as a kitchen nuisance, and popularly called a "black beetle." A more inappropriate name than black beetle could hardly be conceived: the epithet "black" is apparently applied in a loose sort of way to indicate merely a dark colour, for, when closely examined, the creature is seen to be really reddish brown of a deeper or brighter tinge according to age and sex, only approaching black in the older females, and then merely on the back. Again, in many important structural characteristics as well as in the nature of the changes it undergoes in the course of its life, it is widely removed from the true beetles. Not but that there *are* black beetles (*Blaps*, &c.) rightly named, that domicile themselves with man, lurking in cellars and outhouses; but these are totally different insects from *Periplaneta orientalis* (fig. 1), the common cockroach, with which we are now concerned, and they never appear in enormous swarms in our kitchens as the cockroach frequently does.

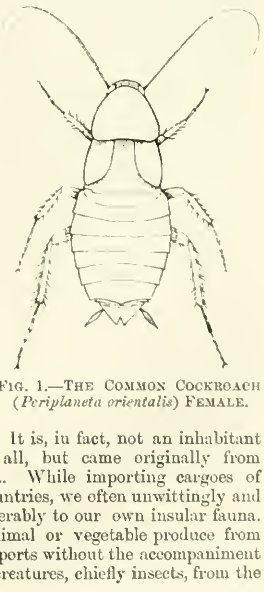


Fig. 1.—The Common Cockroach (*Periplaneta orientalis*) Female.

English soil did not produce this much-maligned insect; it is an immigrant from foreign parts. It is, in fact, not an inhabitant of temperate climates at all, but came originally from the tropical parts of Asia. While importing cargoes of the productions of other countries, we often unwittingly and unintentionally add considerably to our own insular fauna. Probably no shipload of animal or vegetable produce from distant lands starts for our ports without the accompaniment of an assemblage of living creatures, chiefly insects, from the

same parts of the globe. Such of these as survive the voyage stand a chance, after unshipment, of becoming naturalised, if only they can speedily find suitable food and a locality which yields a congenial temperature. Amongst such established importations, of which we may now count some dozens of examples, the common cockroach stands pre-eminent as regards both size and numbers, and is probably as cordially hated as any of them except the bed-bug. When the first Asiatic cockroach set foot in Britain, it is impossible to say with certainty, but it was probably not more than about four centuries ago. By the end of the sixteenth century, they had been introduced into the two chief maritime countries of Europe—England and Holland; but we do not get any specific notice of them in zoological literature till near the middle of the seventeenth century, when we read of them as found in flour mills, wine cellars, &c., in England. At this early date, it was, of course, only the seaport towns, and principally London, that were frequented by the insect, and it took a long time to spread to inland and country districts—indeed, in all probability, the conquest of England by the cockroach is hardly yet complete. Gilbert White, writing towards the close of the last century, speaks of the cockroach as an unusual insect in the village of Selborne, saying that he had never seen it in his house before, and no doubt there are even now remote country places whither it it has not yet penetrated.

Cockroaches are strictly nocturnal in habits, seeking in the daytime the utmost concealment. Hence it happens that they often exist in our houses in multitudes that are perfectly unsuspected until one surprises them in their midnight revels. You visit the kitchen after the lights are out; and as you approach a faint rustling, like the rattling of distant rain, or the pattering of tiny feet, catches your ear. You throw a light on the scene, and on the floor stands revealed a sort of Pandemonium, crowded with dark forms hurrying hither and thither, hastening to get into obscure corners away from the glare of the hateful and unexpected light. But when you go in again by daylight they have all disappeared, and no trace of them can be seen. They have packed and squeezed themselves away into niches, cracks, and crevices, under sacks or matting, behind jars or pans, or even under boards, bricks, or stones—anywhere to be out of the light. The flatness of their bodies gives them unusual facilities for thus bestowing themselves.

They have a double reason for frequenting the kitchen premises. First, a tolerably high temperature is essential to their well-being, as might be expected of importations from the tropics; they cannot stand cold, and much less than the frosts and snows of winter is sufficient to kill them. Therefore they have the good sense to take up their quarters in that part of the house where artificial warmth is most constantly kept up. Then, again, the kitchen regions are the land of plenty, and contain things edible to a greater extent than the rest of the house. Not that they are at all fastidious as regards diet; the most unpromising materials yield them sustenance, and they will absolutely thrive on what might have been supposed to be totally innutritious. They are truly omnivorous; articles of human food, both animal and vegetable, are much to their taste, but they do not stop at these; woollen clothes, newspapers, blacking, ink, leather, and even emery paper will do equally well, and they will even devour their own cast skins, and enjoy a cannibal feast on the corpses of their relations. Professor Moseley records how, during the circumnavigating voyage of H.M.S. *Challenger*, a number of cockroaches, stowaways on the voyage, established themselves in his cabin, and devoured parts of his boots, "nibbling off all the margins of leather projecting beyond the seams on the upper leathers."

The same naturalist gives an amusing account of the attempts he made to rid himself of one particularly unpleasant visitor (apparently a different species from *P. orientalis*, though of similar habits), which seems to have manifested a considerable degree of intelligence. He says: "One huge winged cockroach baffled me in my attempts to get rid of him for a long time. I could not discover his retreat. At night he came out and rested on my book-shelf at the foot of my bed, swaying his antennæ to and fro and watching me closely. If I reached out my hand from bed to get a stick, or raised my book to throw it at him, he dropped at once on the deck, and was forthwith out of harm's way. He bothered me much, because when my light was out, he had a familiar habit of coming to sip the moisture from my face and lips which was decidedly unpleasant, and awoke me often from a doze. I believe it was with this object that he watched me before I went to sleep. I often had a shot at him with a book or other missile as he sat on the book-shelf, but he always dodged and escaped. His quickness and agility astonished me. At last I triumphed by adopting the advice of Captain Maclear, and, shooting him with a pellet of paper from my air-gun, a mode of attack for which he was evidently unprepared."

On board ship cockroaches, of one kind or other, often do much damage. Mr. R. H. Lewis speaks of two kinds of them attacking a cargo of 300 cases of cheeses. Holes had been left in the packages to prevent the cheeses from "sweating," and the cockroaches thus found entrance and damaged them considerably, devouring a great quantity and befouling all. Their disgusting odour, arising from a fœtid fluid poured out from the mouth, renders them far more obnoxious than they would otherwise be, and often causes food to be spoiled by their proximity.

In the perfect condition the male and female cockroaches differ considerably. The males are smaller and less robust than the females; they stand higher on their legs, *i.e.*, do not allow their abdomens to trail along the ground as their partners do, and are furnished with two pairs of wings, the females being apterous, or nearly so. The upper pair of wings, called *elytra* or *tegmina* (fig. 2, A) are rather stiff and horny, and being dark coloured, do not easily show the very peculiar course of the so-called nervures; but the under pair, called specifically *wings* (fig. 2, B) are membranous and transparent, and the nervures can be easily seen. In repose the wings are folded in half lengthwise, the inner half being bent under the outer, and then itself folded like a fan, and they are then covered by the elytra much as in a beetle, though in that case the folding would be transverse instead of longitudinal, and the elytra would not, as they do here, overlap. When closed the elytra cover the greater part of the back. The females simply have a rudimentary pair of elytra (see fig. 1) and no wings at all, and flight is impossible to them.

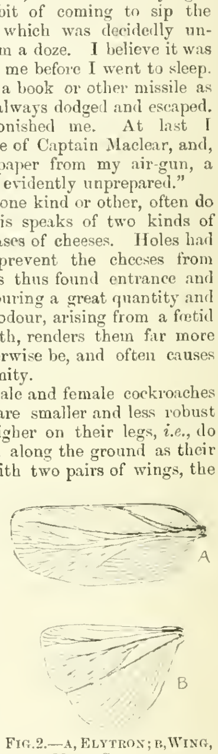


FIG. 2.—A, ELYTRON; B, WING, OF MALE COCKROACH.

A cockroach issues from the egg, not, like many insects, with a form totally unlike that of its parents, but shaped very similarly to the adult, and differing from that chiefly in its minute size, its pale colour, and the absence of wings. These young cockroaches may often be seen in kitchen hearths in great numbers—little pale whitey-brown creatures, running about with extreme agility, and moving their legs so quickly that they seem to skim along or glide over the ground. As they grow, like other insects they cast their

skins periodically, after each moult becoming larger and darker. During the first year of its life the young cockroach changes its skin three times; the first immediately after hatching, the second a month later, and the third not till the end of the year. There would appear to be seven moults in all before the fully developed form is attained, but after the first three these are made only annually. This, at least, is the conclusion arrived at by Cornelius from observations made on captive cockroaches; but it may be open to question whether the course would have been precisely the same under more natural conditions, and, unfortunately, no other observations have been recorded on this particular species. If, however, the above results represent the usual state of things, cockroaches are certainly gifted with extraordinary longevity, for their life evidently extends over a period of at least five years. One is accustomed to think of insects as truly ephemeral creatures, and it is probable that the majority of them do not require more than a single twelvemonth to complete their cycle of existence; where the preliminary stages occupy a longer time than this, the species chiefly feed in concealment—as buried in the ground, like the grubs of the cockchafer, or in solid wood, like those of the stag-beetle. The experience of Sir John Lubbock with his ants has, it is true, demonstrated that the life of insects may, under favourable conditions, last much longer than we should have expected. Some of his ants lived with him upwards of eight years; but these were in their perfect condition all that time, and their early life and periods of transformation and growth had been, as usual, rapidly accomplished. Cockroaches, on the other hand, if the above results are to be accepted, take a long time to pass through their introductory stages, but we have no evidence at all as to how long they live after becoming full-grown. To so active an insect the dangers and possible mischances of a long larval life would necessarily be very numerous, and it is highly probable that great numbers of them would never reach maturity at all. Be that as it may, their swarms are still quite large enough for human comfort. Further observations on their life history, however, are much to be desired, though no doubt difficult to carry out. A closely allied species, *Blatta germanica*, was studied by Hummel with a very different result, the generations being found to succeed one another with much greater rapidity, and analogy suggests that *P. orientalis*, which is similarly an active surface-living insect, should run a similar course, and should, at any rate, complete its cycle of changes more rapidly than sluggish grubs which live in solitariness and concealment.

(*To be continued.*)

THE PRODUCTION OF SUGAR.

By Ward Coldridge, B.A. Cantab.

YESTERDAY the formation of sugar by plants was one of the mysteries of nature. Chemists and botanists, whilst they knew that ordinary chemical attractions must be the cause, were yet completely in the dark as to how these forces worked. They realised that plants started with carbonic acid and water, and from these waste products of animal existence built up in some unknown way the complex compound, sugar. From the deadly choke-damp to the luxury sugar was a great transformation. The plants could thus build; but men of science could not comprehend the process.

To-day, as the result of some brilliant researches, the explanation has been found. A simple compound, the formation of which by the plant can be readily accounted for, has been transformed into a sugar. To understand the process, it must be realised that abundant evidence proves that plants promote processes which are the opposites of combustion or oxidation. Plants liberate oxygen from its compounds, and absorb that with which it was previously combined. They can liberate oxygen from so stable a compound as carbonic acid, and in water find a source for the hydrogen which is essential to their development. The products which could thus be formed are, respectively, from carbonic acid, the lower oxide of carbon and oxygen, from water, the gases hydrogen and oxygen. Experiments have shown that under the influence of the silent electric discharge, and even without it, carbon monoxide and hydrogen combine to form a simple compound, formic aldehyde, which is immediately connected with the formic acid of the ant and of the stinging-nettle. So the changes which occur in the plant under the combined influence of sunlight and chlorophyl may be represented in symbols as follows:—

$$\underset{\text{Carbonic acid.}}{CO_2} = \underset{\text{Carbonic oxide}}{CO} + \underset{\text{Oxygen}}{O} \quad ; \quad \underset{\text{Water}}{H_2O} = \underset{\text{Hydrogen}}{H_2} + \underset{\text{Oxygen.}}{O}$$

$$CO + H_2 = \underset{\text{Formic aldehyde.}}{CH_2O}$$

This formic aldehyde was the substance experimented on. When it was suitably treated in the presence of the hydrate of lime ($Ca(HO)_2$), it was induced to combine with itself and to form another compound. The latter is composed of the same ultimate indivisible particles (atoms) and in the same proportions; but they are now differently arranged side by side, and with a larger number in the unit aggregation which chemists call molecules. This compound has now been finally proved to contain not one, but at least two or three members of the family of substances, carbohydrates, to which sugar belongs. Thus in our laboratories can now be imitated the process of which plants previously held the secret.

Whilst, however, the fact is marvellous that a sugar has been obtained artificially, it must be remembered that the process is absolutely uneconomical, for the yield is very small. This remark too applies to another process of artificial production. The sweet viscid liquid, glycerin, and its stinking, irritating offspring, acrolein, which gives the nasty smell of burning fat, have both been transformed into sugar; but the quantity obtained is very small in proportion to the glycerin or acrolein used. The importance of these researches lies in the fact that they show how the chemical changes which characterise the vital action of the plant can be imitated with dead matter, and that further they shed a bright gleam of light on the hitherto obscure question of the arrangement of the indivisible particles, atoms, within the compound particles, the molecules of these substances.

Our supply of sugar will always be drawn from the vegetable kingdom, the synthetic laboratory of nature. Many plants work hard and economically at the production of sugar, and form it in quantity. It occurs in all parts of plants—root, stem, leaves, flower, fruit, and seed. In some grasses it is very abundant, in the sugar-cane, in the Sorgho grass, and in the young shoots of the maize. In the common carrot and parsnip, and especially in the fleshy beet, large quantities are contained. But for its commercial extraction two sources are chiefly used—the sugar-cane and the beetroot, and a third is of growing importance, the Sorgho grass.

The sugar-cane has far greater natural advantages than the beetroot. At one time the former held the field without a rival. But during the Napoleonic wars, France was deprived of her supply of sugar, and she was driven to

produce her sugar at home. This resulted in the commencement of the beet-sugar industry, and thus amongst the secondary results of war must be reckoned bounty-fed sugar. To judge of the economic aspects of the two industries, many factors have to be taken into account. When that has been done, this balance will be found distinctly in favour of the cane. Sugar-canes contain sufficient sugar to yield 70 to 80 per cent. of their weight of juice, in which there is some 20 per cent. of sugar. Beetroots, as an extended series of investigations have shown, possess a percentage of sugar varying from 7 to a maximum of under 14, and on the average about 11. Now an acre of land which can be used for beet-growing will be rented for, say, 4*l*. per annum, whilst in the colonies an equal area of cane-producing land will be rented for about one-tenth of that amount. Further, a great divergence is found in the quantity of beet and cane which two equal areas can grow. For instance, in the environs of Magdeburg, an acre will yield about 10 cwt. of sugar; whereas, in the home of the sugar-cane, some 40–50 cwt. can be obtained. Then other items in the cost of production have to be considered; the difference in wages in the two regions, the difference in the cost of fuel—in Europe where coal is necessary, in the colonies where the waste matter of the cane supplies the whole, or nearly the whole, of the fuel required. One can thus realise the grounds on which the Brazilian Commission on the sugar industry reported, that, in their opinion, "the cost of production may be reduced in Brazil to such a degree as to defy competition, and the struggle between cane and beetroot must become ominous to the latter, which thrives only by the artificial advantages which European countries have devised."

Hitherto the artificial advantages have been on the side of the European countries; but now the greatly improved means of transit, and the diffusion of knowledge, are raising the colonists to a position nearer equality in these respects, of course excluding bounties. And by this time the colonial sugar planter has learnt a severe lesson. He understands that, whilst nature has showered her gifts on him with a lavish hand, she mercilessly punishes him for carelessness and lack of promptitude. For if he cuts his canes, they must within a few hours be crushed and extracted; if he is negligent, and leaves them for only two days, fermentation rapidly ensues under the conditions of tropical temperature, and the canes turn sour and must be thrown aside for fuel. In this way nature has fined men whole fortunes. Great fortunes have been made in the manufacture of sugar; but of these processes, with their special points of interest, an account must be reserved.

EARTH-WORMS—II.

By E. Mansel Sympson, M.A., M.B. Cantab.

LET us look for a minute at the diagram, which represents a section of the earth-worm's body cut clean through the middle, as it will give a clear idea of the relation of parts inside the worm. On the outside, all round, you see there is the skin (a in the diagram) pierced in four places by pairs of hairs (δ) which have special muscles at their inner ends to make them stand on end, as indeed our own hairs have, but they are little used by us save when we see a ghost, or think we do. Beneath the skin come the circular bands of muscular fibre; within those again are four bands of longitudinal muscle, cut across. Then we come to a space—the body cavity, which you remember was formed by the hollowing-out of those masses of mesoblast. This communicates with the outside world in each segment by a couple of coiled and curved tubes, opening at one end into the cavity of one

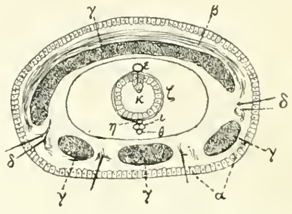


Fig. 4.—Transverse Section of Mature Earth-worm.
a, epidermis; β, circular muscles; γ, longitudinal muscles; δ, hairs; ϵ, dorsal blood-vessel; ζ, "heart;" η, sub-intestinal blood-vessel; θ, sub-neural blood-vessel; ι, double nerve-cord; κ, intestine, with dip (Typhlosole) from upper surface.

segment, running through the partition-wall, and out through the body-wall of the next segment. They are plentifully supplied with blood, and serve as kidneys for the animal. On the upper surface of the intestine you see the dorsal blood-vessel, with the so-called heart leading down to join the sub-intestinal vessel; below the latter is the double nerve-cord, and below that the sub-neural blood-vessel. Then in the middle is the intestine cut across, with its muscular coat and special lining membrane and that curious dip from its upper surface. No special breathing-apparatus is found, as worms breathe by their skin. The two sexes are united in the same individual, but two individuals pair together. As for senses, the earth-worms are rather badly off. They have no eyes, and have been thought quite insensible to light. But Mr. Darwin found that when the light was concentrated and long-enduring they certainly showed some perception of it. This, however, only occurred when the light was allowed to fall especially on the anterior end of the body; consequently it probably affected the ganglia above the pharynx by passing through the skin. In the rest of the body you will remember the nerve-cord and ganglia lie directly under the intestinal canal, and so are more shielded from the action of light. Probably this perception of light is quite enough—poor as it may seem—to enable them to distinguish between day and night. Somewhat in the same way as we go to sleep at night twenty-four hours after twenty-four hours, so do the earth-worms disappear into their burrows at the dawn to reappear with the darkness of night. It seems to have become an habitual action with them, incapable of being changed with changed conditions, for a number of worms kept by Mr. Darwin in pots covered by glass plates with black paper spread carefully over, and placed before a north-east window, behaved exactly as worms generally do—they came out at night and remained in their burrows during the day. Earth-worms also are quite deficient in the sense of hearing; they will take no more notice of the shrill, ear-piercing note of a penny whistle than of the deepest and loudest tones of a bassoon. But worms are wonderfully sensitive to vibrations in solid matter; when placed in pots on a piano which was being played, one gentle note was quite enough to send them back into their burrows, like a rabbit to his hole. And a common way of catching worms is to beat the ground with a spade, whereupon they come out in numbers. All over its body is the worm sensitive to contact. A slight puff of air will cause an instant retreat; but the most highly developed part in this respect is the oral end, by moving which about it gains a general im-

pression of the size and shape of surrounding objects. Their sense of smell is shown in the choice and selection of different kinds of food. Cabbage-leaves and bits of onion, buried beneath a $\frac{1}{4}$-inch of earth, were almost greedily run after; the worms in well nigh every instance discovered them, and dragged them out. As you might fairly expect in an animal so comparatively omnivorous as the earthworm, he possesses a very decided sense of taste. Onions, cabbage, the common or garden green cabbage especially, are liked by them. Celery they devour seemingly with a relish. They also manage to swallow an enormous quantity of earth. They don't object to liquorice. They don't mind whether their meat is cooked or raw; but, above all else in the meat line, a bit of raw fat seems to titillate their palate most. Cannibals are they, for they will gnaw away unconcernedly at the half of a dead brother's body; but you cannot expect much sentiment in an animal with only two cerebral ganglia to represent its brain, and six pulsating arteries for a heart. Their digestive fluid differs in no respect from that of higher animals: it acts on fat, on the fibrin of meat, on starch, and on the cell-walls of leaves and other parts of plants, a very useful thing, you can imagine, for an animal which lives chiefly on half-decayed leaves, whereof the cell-walls are almost three-fourths of the nutriment, for of course the meat diet is not obtained save by one in a thousand, who happens to fall in with a kindly collector. Earthworms take kindly to milk, in which it would be a good thing if more of mankind imitated them. Also it is interesting to note that the secretion wherewith worms moisten the leaves they drag into their burrows partially digests them, which may remind us of the digestion of flies, &c., on the leaves of the sundew.

The distribution of earth-worms is wide, almost universal. In England they inhabit the commons and chalk-downs as well as the London parks, with their different qualities of soil. In the grassy paths across moors they abound, and in paved courtyards you may often come across evidence of their presence. Their castings have been found at various heights from 1,500 to 4,000 feet above the sea, on Schiehallion in Scotland, on some hills near Turin, and on the Himalayas. You count them terrestrial animals, that is, animals which inhabit the earth, though they have been kept alive for nearly four months completely submerged in water. Also they want a damp air to live in, as was proved by exposing some to the dry air of a room for a single night: in the morning they were all dead. A few remarks here on their relations and the class to which they belong seem to fall in naturally. One, almost the nearest, of their relations is the leech—everyone knows the medicinal one, if they do not know the common horse-leech of ponds. Then there are fresh- and salt-water worms. When you examine the latter, which generally secrete a tube wherein they dwell, such as the beautiful *Serpula*, with its crown of tiny ostrich feathers, you find they have a special apparatus — the gills — whereby they breathe. Most people must have seen the coils of sand which are so frequent between high and low water-mark on the shore, and to explain whose construction saintly or demoniacal aid has been invoked. These are the casts of the lug-worm, greatly in demand for bait. Then the free-swimming *Nereids*, as they are prettily called, are worms of wonderfully exquisite colour, changing with each movement of the animal. The sea-mouse, *Aphrodite*, too, comes near to these, with its hairy coat sparkling in the sun with every imaginable play of colours. It is also notable as having gills of rather curious construction on its back, acting somewhat like the respirators wherewith people try to mitigate the piercing chill of a "wild north-easter."

Most families, if not all, have, they say, some poor relations, or, if not exactly poor, so disreputable that they never mention them. The earthworms are no exception to this rule. Their parasitic relatives must not be mentioned to ears polite. That word parasitic recalls something about the leech. You may count it as a parasite, since it lives on the blood of other animals, and as such obeys the same laws as other parasites. In common conversation, when we call a man a parasite, we mean to imply that he is a degraded being: it is much the same among animals. You will almost universally find that a parasitic animal has become degraded from what is believed to be his original position in his class. Somewhat in the same way as an endowment or an assured position has been the ruin of many a man who might have turned out a fine specimen of humanity if he had had his own way to make in the world; so, when your animal gets a great deal of the work of procuring and preparing food done for him, he gets lazy and sinks lower in the scale of animal life. The neighbouring classes to the earth-worms are lowest of all the Protozoa, already mentioned, containing the *Amœba*, *Ophrydium*, and the like. Then the Cœlenterata, with *Hydra*, the sea-anemones, and the jelly-fishes. Next we get to the Echinoderms, some of which are known much better by their commoner name of star-fishes. Our earthworms and their relations form the class above; while just above them, in turn, come the Arthropods, including lobsters, centipedes, spiders, and insects. Above them, again, are the mollusks, the fresh-water mussel, the oyster, and the common snail.

Now to turn to a more interesting part of my subject—the habits of earth-worms. I mentioned that their upper lip was useful for seizing articles of food; they take hold of the edge of a leaf, for example, between the upper and lower lips, with a very firm grasp. But when they have to deal with broad flat objects, they act in a totally different way. The anterior end of the body is withdrawn a little within the first three or four segments, so as to form a flat end to the body; this flat end, something like the end of a pencil-case, is then applied to the cabbage-leaf or a slice of onion, and a vacuum is produced whereby the worm gets a tight hold of it. Worms are fond of leaves, not only as food, but also to use for plugging up the mouths of their burrows, and for lining their walls, probably so as to protect their bodies from the cold earth around. They also protect the mouths of their burrows with little heaps of stones, which they drag from some distance—by suction as well. Mr. Darwin thought these plugs were apparently to keep out the cold air, and to keep the air already within thoroughly damp, which, as we have seen, is essential to a worm's happiness, and even to his existence. Now the manner in which these leaves were dragged into the burrows is interesting. As the tip of a leaf is generally the smallest and narrowest part of it, probably if you or I had to use these leaves for wall-papers in our "diggings," we should drag them in by the tip. Mr. Darwin examined over two hundred leaves of different kinds which had been in the earthworms' burrows, and nearly eighty out of each hundred had been dragged in by the tips. A good number of these were leaves of the lime, which are very pointed at the top, and gradually swell out to a broad base with a well-developed foot-stalk. The rest of these leaves were drawn in partly by their base, partly by their middle,—probably the stiffness of the leaves had a great deal to do with this latter portion. Then Mr. Darwin tried the leaves of laburnum, which are quite as pointed at the base as at the tip; and the worms dragged a good many more of these in by the base, nearly thirty out of a hundred. But still, the larger part by far were dragged in by their tips, showing that worms have probably acquired

the habit of avoiding the footstalk, unless the leaf, by narrowing down to it, makes things more even. Also pine leaves, consisting of two needle-like blades, joined to a common base, were almost invariably drawn in by that base. Mr. Darwin observed many worms by a dim light actually dragging these and other leaves into their burrows, and he remarks, "It appeared to my son and myself as if the worms instantly perceived as soon as they had seized a leaf in the proper manner." And I have examined a good many split seed capsules of the laburnum, which the worms seem very fond of; and they were almost always drawn in by the tip and not by the base. Now, as worms are not guided by special instincts in each case, though possessing a general instinct to plug up their burrows, and as chance is excluded, the most probable conclusion is that they try a variety of ways of drawing an object into their burrows, and at length succeed in some one way to which they stick. But it is rather putting the cart before the horse to tell you of the lining of the burrows, when I have said hardly a word about the mode of making these burrows. This is done in two ways, partly by the anterior end of the worm acting as a wedge, and so pushing the earth away on all sides, and partly by the worm actually swallowing the earth. The two modes of action seem to be chosen with regard to the character of the earth in which the worm is burrowing. For instance, in loose garden soil, they were observed many times in the act of making their burrows; but they appeared to swallow little if any of the soil. Again, in fine sand which had been pressed down and well watered, they swallowed a large quantity. Earth-worms undoubtedly do swallow a good deal of earth—especially the dark vegetable mould—for food, and it is only on this plea that we can explain the multitudes of castings you can see each morning, which are quite inexplicable if we suppose these are only thrown up like piles of bricks and mortar, when the inhabitant is enlarging his house or building a new one. As a rule the burrows are not deep, but in cold weather, as well as in cold countries such as Scotland and Scandinavia, they have been noticed to run down for 7 or 8 feet, and Mr. Darwin says that in England he has frequently known them extending downwards for 3 or 4 feet. They are generally lined by a layer of dark and fine earth which has passed through the worm's body, they generally run straight down, and are rarely branched. When you look at an earth-worm's burrow, you would think it certainly never could turn round inside. But it must do so, for the excretion of the earth or casting is done with its tail first on one side and then on the other, and the tail is used almost like a trowel, while the mouth catches hold of leaves. These castings vary greatly in size: some of the largest ever measured were 6 inches high and $1\frac{1}{2}$ inches thick. There are two methods of estimating the quantity of earth brought to the surface in any given time: one by the rate at which objects left on the surface are buried; another, a still more accurate way, by weighing the quantity brought up within a given period. Let us take an example. Mr. Darwin in his book on earth-worms (from which a good deal of the information in this paper has been gathered) states that a piece of waste swampy land near to his house was enclosed, drained, ploughed, harrowed, and thickly covered with burnt marl and cinders in the year 1822. It was sown with grass-seed, and now supports a fair but coarse pasture. Fifteen years after, i.e. in 1837, holes were dug in this land. It was found that the turf was $\frac{1}{2}$ inch thick, beneath which was a layer of vegetable mould $2\frac{1}{2}$ inches in thickness. It was quite free from any fragments of any kind, but beneath it again was a layer of mould $1\frac{1}{2}$ inches thick, full of bits of burnt marl, conspicuous from their red colour, and coal cinders. Below this layer, and at a depth of $4\frac{1}{2}$ inches from the surface, was the original black peaty soil with some quartz pebbles in it. Thus in only fifteen years a layer of fine vegetable mould $2\frac{1}{2}$ inches thick had covered the land. Now as to the weight of the castings. When kept in confinement, it has been found that they only gave out eight grains daily. But when you weigh separate castings obtained out of doors, some actually weigh over an ounce each. Off a small piece of turf about 22 feet square, I have collected at one sweep nearly two pounds of castings. In England the largest castings are found in the poorest land, as though the worms had to swallow more earth to get the same amount of nourishment from it.

OUR MICROSCOPIC FOES.

OUR DEFENCES.

By A. WINKELRIED WILLIAMS.

IN guarding ourselves against an enemy we should always keep three things in mind: how to act on the defensive against attacks by the foe; how to act on the offensive, and destroy or disable the foe; and how, should defeat be overshadowing us, to take advantage of the better part of valour, and run away. So in the Bacterio-Human war must we be ready with an effective combination of the above three actions in order that the victory may be ours. When all the forces of our bodies are acting in unity—that is to say, when we are in our natural condition of perfect health—we are practically invulnerable against the foes' attack, unless it be made by an abnormally great multitude. We are naturally encased in a suit of armour wondrously and perfectly made. A layer, or series of layers, of epithelial cells covers every surface of the body; these cells are carefully cemented together by a small amount of interstitial matter. The armour varies in structure according to the requirements of the different surfaces which it covers and the functions these surfaces perform. The beautiful manner in which the structure is adapted to the function is well seen by examining the epithelium covering the skin and the respiratory surfaces.

The function of the skin epithelium, exposed as it is to great friction and to bacteria innumerable, is mainly protective. It consists of many layers. The cells in the lower of these layers are formed of soft protoplasm, and are continually multiplying. As they grow older they become flattened and horny, until on the surface we find scales of horny keratin; these are continually being rubbed off. The skin, however, has also another function, *i.e.*, the secretion of sweat. Accordingly we find the epithelium altered in places so as to form sweat glands; these consist of tubes of a delicate epithelium. This delicate epithelium is protected by a very fine and comparatively long and tortuous duct leading to the surface.

In the respiratory passages we find other forms of epithelium. In the pharynx and larynx we have a stratified squamous epithelium resembling the skin surface; below this we have a far more delicate and beautiful arrangement. The windpipe divides into the two main bronchial tubes; these subdivide over and over again and finally end in narrow passages, around which are clustered a number of minute vesicles just visible to the naked eye. These passages, excepting the terminal ones, are lined by a stratified ciliated epithelium, which is modified here and there into mucous glands and mucous cells. The surface cells are the largest, and are provided with many minute cilia. These cilia are continually moving in such a manner

as to allow the mucus secreted by the glands to be gradually moved upwards. When bacteria and other particles are inhaled they are drawn down into the larger bronchi by the inspiratory effort, and come in contact with the lining epithelium with its covering of sticky mucus; to this they adhere and are lashed up by the cilia to be expectorated. The terminal air vesicles and passages, where the exchange of gases between the blood and the atmosphere chiefly takes place, have a lining of only a single layer of flattened cells. Two circumstances protect these: firstly, in ordinary respiration the air is not drawn down to these cells with any force, it merely diffuses into them, and the bacteria probably would have been caught by the mucus above; secondly, the nervous mechanism here is readily stimulated by an irritating particle such as a tubercle bacillus, and the result is a forced emptying of the passage by a cough, which drives upwards the irritant. When by any chance the healthy continuity of the epithelium is broken and the entrance of bacteria allowed, there is still a battle to be fought. If the injury has not seriously lowered the vitality of the tissues, most bacteria will have but a poor chance of life. There are the scavengers already referred to; normally their vitality exceeds that of the bacteria they devour. The chemical processes occurring everywhere in our bodies also do much to destroy bacteria. Possibly also the rapidity of the blood-stream may have something to do with their destruction; we know that active motion is antagonistic to their life outside the body, and therefore the same influence may act within.

It is of course possible for an army, if sufficiently numerous, to overcome defences, however complete they may be. The admirable natural defences of the healthy living body can be thus broken down by abnormally great numbers of bacteria. In Koch's experiments on the tubercle bacillus, he showed that the inhalation of them in great numbers by healthy guinea pigs readily caused tuberculosis; the injection of them into the blood produced the same result. Another striking example is the case of the micrococci of suppuration; if we apply a poultice of these to the human skin a boil results. In nature, however, we are practically never exposed to such extreme conditions. There are also certain bacteria whose virulence is so great, that probably but few of us could resist them when once introduced into the system. Such is the case with the bacillus that causes that fatal disease of cattle called anthrax, and which often causes a similar disease in men, especially among farriers and wool sorters.

We now come to the consideration of the second method of defence, viz., how to destroy and disable the foe. An important way of getting rid of our bacterial foes is to cut off their supplies, destroy their habitations and means of locomotion. In towns the proper attention to sanitary arrangements, the proper disposal of the drainage, the efficiency of the water supply, the cleanliness of the streets, houses, and people are some of the principal modes in which this part of the warfare can be carried on. The avoidance of dust is also important. It has already been stated that the bacteria in the air are principally carried by particles of dust; but another reason is that the continual inhalation of many particles of dust by itself causes irritation to the lungs, and is apt to produce chronic inflammatory mischief, the results of which give opportunities for the entrance of bacteria. Thus in many trades, such as needle-grinding and stone-cutting, the proportion of deaths from consumption is terribly great.

The direct destruction of bacteria by implements of war is also demanded. The principal implements we use are poisons and heat. These we term disinfectants and antiseptics. The disinfectants are those which directly kill the organisms and their spores, the antiseptics those that hinder their development and stop their spore formation. Important poisons are corrosive sublimate, carbolic acid, arsenic, chlorine, and many others. Their relative value cannot be discussed here; in fact, it is a subject much disputed. By these agents we can destroy the bacteria where they are known to exist to a dangerous degree, such as in fever chambers, mortuaries, drains, &c. Their use in epidemics is evident.

Heat is a disinfectant, and, moreover, it is one of the most important we have. Dry heat is less powerful than moist heat: in using it the temperature of over 284° Fahr. must be prolonged for some time to make sure of killing both the organisms and their spores, while steam at 212° rapidly kills all bacteria. Heat is greatly used to disinfect clothing, &c., and the heat used in cookery is an important agent in times of epidemic, especially of diseases affecting the alimentary tract, such as typhoid and cholera. In these cases the boiling of water and of milk is very important. In reference to tuberculosis, the boiling of milk is a matter of very serious importance, especially in towns where cows are kept in stables for dairy purposes. Cows under such unnatural conditions are very apt to become tubercular, and unfortunately when affected they may shew but little or no external evidence of the disease. The milk of tubercular cows very frequently contains a great abundance of tubercle bacilli; hence the danger. Epidemics of scarlet fever have also been traced to the use of unboiled milk.

It is a common practice in warfare to make our enemies destroy each other. We can sometimes do this with the foe under consideration. Some bacteria thrive on certain soils much better than others; these will outgrow and starve out the less favoured. In some cases such antagonistic actions can take place in the body. For example, there is an antagonistic action between the anthrax bacillus and erysipelas micrococcus. If we take two animals susceptible to anthrax disease, and inoculate them both with the bacillus, then a short time afterwards inoculate one of them with erysipelas virus, the result is that the one which has simply had the anthrax inoculated dies, the other lives. It is one of the great aims of modern medical investigations to try and cure grave diseases by giving the patient another of a comparatively trivial and curable character. In connection with this we recognise the friendly actions of some bacteria, which, although unpleasantly stimulating our olfactory apparatus by their volatile secretions, do us great service in choking out others that might be a source of serious danger.

There are many bacterial diseases of which one attack, even though of the most trivial character, protects the patient from a future attack. The reason of this is at present a mystery. From this it is evident that, if we can disable the power of bacteria, so that a slight attack may be given, a great advantage is obtained. This has been done in several ways—by giving the disease to a different animal, and collecting the virus from it; by cultivating the organisms in some non-living medium for many generations, or by cultivating them under some peculiar conditions, such as excessive heat. The earliest and by far the greatest good done for mankind in this way was through the researches and brilliant discovery of vaccination by Edward Jenner many years before such things as bacteria were even heard of. He discovered that smallpox, after having passed through the cow, was converted into a disease so simple as to cause only the trivial results of proper vaccination. Vaccination does not give complete immunity from smallpox, but mitigates its character; by it one of the most horrible of diseases, malignant smallpox, has practically ceased to exist, and in its place we find a comparatively trivial disease, *i.e.* the smallpox of the present day.

In late years mitigation of the virus of other diseases has been accomplished by repeated cultivations. Anthrax was firstly so mitigated by Professor W. S. Greenfield. M. Pasteur afterwards made similar investigations on anthrax. While Professor Greenfield was mitigating the anthrax bacillus, M. Pasteur was doing the same with fowl cholera, and published his results at about the same time. The bacteria of acute pneumonia also have their virus rapidly weakened by successive cultivations. Later still are the results of Pasteur in mitigating the virus of hydrophobia.

We now come to the consideration of the last part of our defences, *i.e.*, the ways of safe retreat. The first great thing is to get fresh air. The proper ventilation of our houses is now well known to be an absolute necessity for the maintenance of health, and it is a subject directly connected with the bacterial question. For when we ventilate our houses we not only get a fresh supply of oxygen and get rid of carbonic acid gas, but we at the same time get rid of the dusty and bacteria-laden air that is found in crowded localities. But even the best arrangement of ventilation is not sufficient in crowded workshops; this, however, can be remedied by those who live in such places taking a few hours of vigorous outdoor exercise daily. The exercise should be vigorous, so that the stagnant air in the lungs may be got rid of, and that the lungs may be well dilated with fresh air. The necessity for this is greater in men with big chests. The lungs of such men when they do not have proper exercise are not fully dilated, and are apt to become contracted and unhealthy at the apices, thus leaving a convenient place for the insidious attacks of the tubercle bacillus. The truth of the above statement is painfully exemplified in the case of shopmen who are confined in shops, often ill-ventilated, and who have no proper time for daily exercise excepting Sundays, when they are often too tired to take advantage of a day with few outdoor attractions. It is here that we very frequently find victims of consumption. It is also an important matter that we should be able to occasionally leave the town for a week or two in order that we may recruit our strength and repair any point in our defences that may be weakened by the foe's attack, and of course this can be done more thoroughly when as few of the enemy are about as possible.

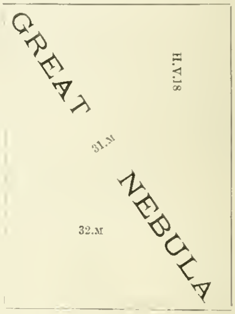
There are some people who should never live in crowded towns. I refer to those belonging to consumptive families. We have all heard of hereditary consumption; it is, however, extremely doubtful whether a child is ever born consumptive; the evidence goes to show that children are born with a tendency to tuberculosis, not with the disease actually existent. Such people should live in a mild climate, a climate as nearly uniform as possible and in country places, better by the sea. By this and by living regular lives, the chances of the disease may be decreased. Of course there are immense difficulties in finding the above ways of retreat. How can the majority of mankind get away for holidays in the country? How can they get regular exercise in fresh air? The sooner the above problem can be solved the better for the health, the happiness, and for the morality of the race. For when our bodies are diseased, the cells of our brains cannot act properly, and the strength of our minds depends upon the vigorous action of the little cells of which the active parts of our brains are composed.

Miss C. W. Bruce, of New York, has presented fifty thousand dollars to Harvard College Observatory, which the director, Professor E. C. Pickering, proposes to spend in the purchase and endowment of a photographic telescope of 24 inches aperture. The object glass will be a compound lens of the form used by photographers, and known as a portrait lens. This form of lens permits of a short focus, and gives a large field with good definition.

THE GREAT NEBULA IN ANDROMEDA, 31 MESSIER.

On the opposite page is a photographic reproduction, enlarged about three diameters, from the best negative which Mr. Isaac Roberts has taken of the Andromeda Nebula. It shows a good deal more detail in the outer parts of the nebula than can be traced on the enlargement published with the March number of Knowledge, which is on a smaller scale.

In the picture which we now offer to our readers the nebulous masses breaking up into clusters of nebulous points or small stars which lie along the outer whorl of the great nebula are well shown, and the stellar centre of the small elliptic nebula H.V. 18 is just traceable. All three nebulæ (31 Messier, 32 Messier, and H.V. 18) have stellar centres, but the central parts of the great nebula are entirely lost in the enlargements. On the original negative there are some curious dark patches and branching channels in the neighbourhood of the inner dark spiral and on the more central parts of the nebula. Some similar dark patches or markings can be seen in the enlargement to the north of the small nebula 32 Messier, and at the north following end of the inner great channel, some of the more marked of these dark patches appear to be associated with stars to which they are adjacent. The nebula lies in the neighbourhood of the Milky Way, and we should expect to find as many stars projected upon it, or seen through it, as are to be found in an adjacent area of equal extent, but, making allowance for such stars unconnected with the nebula, there seem to be stream-lines of stars which fall in with the general alignement of the dark channels and the great streams of nebulous matter, as well as evident groups of small stars or nebulous points forming knots of nebulous matter in the outer whorl of the nebula. These are better seen in the original negative than on the enlargement, but some of the knots of nebulous haze on the outer whorl are distinctly shown on the enlargement broken up into nebulous points.



On the original negative no trace of spiral structure can be seen in either of the two small nebulæ, H.V. 18 or 32 Messier. The nuclei of all three nebulæ appear to the naked eye like stars; but when the negative is examined with a microscope, they are seen to differ in character from the other star discs on the plate. They are quite black, but have less definite edges than star discs of equal magnitude. The appearance shown would seem to indicate that there is a rapid condensation in brightness towards the centre, but that there is no stellar nucleus.

It should be mentioned that in order to facilitate comparisons with other drawings, the North point has been placed uppermost upon the page. A similar remark applies to the picture of the Pleiades Nebula given in the February number, while telescopic views with the south point uppermost have been given of the other nebulæ figured in recent numbers of Knowledge. A. C. R.

THE GREAT NEBULA IN ANDROMEDA.

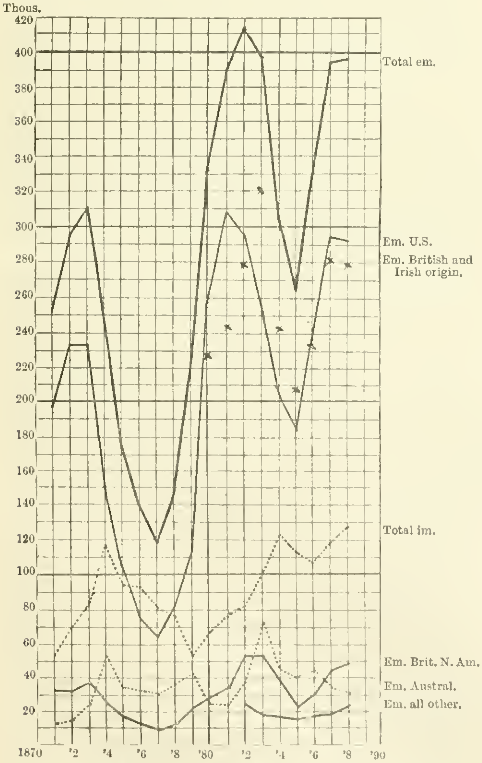
31 Messier, enlarged about three diameters from the original negative taken by Mr. Isaac Roberts, on Dec. 29th, 1888.

EMIGRATION.

By Alex. B. MacDowall, M.A.

PASSING through the variations due to births, deaths, emigration, and immigration, the population of the United Kingdom is supposed to grow at the rate of something like a thousand a day. What do we know, in the statistical way, about those who leave our shores for foreign countries? The annual Government returns of emigration relate to only a portion of this class—passengers, viz., to places outside of Europe (and of non-European ports of the Mediterranean). On the other hand, many of those included in the figures are not true "emigrants," meaning to settle abroad, but of the travelling or tourist class. This is especially true of cabin passengers; who have been rapidly growing in numbers (from 40,000 ten years ago, to 65,000 last year, which is about a sixth of the total of so-called emigrants).

We have, then, to consider the numbers of those who leave our shores for the United States, British North America, Australasia, and other (non-European) countries. The uppermost curve in the first diagram, drawn from figures since 1871, shows that this stream varies greatly in

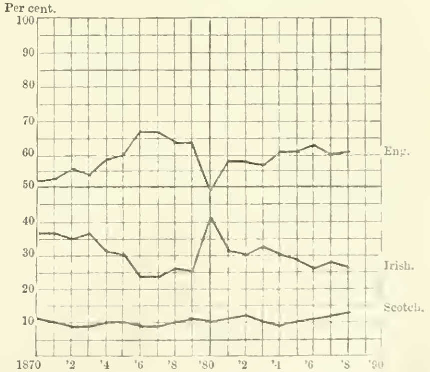


1. Emigration and Immigration (U.K.)

volume. Thus, from 119,000 in 1877, it grew to 413,000 in 1882, *i.e.* nearly fourfold in five years. These were the lowest and the highest figures in this period. A less maximum was reached in 1873 (310,000), and a less minimum in 1885 (264,000). We seem to be now at another turn of the curve from a high point (not so high as in 1882). Last year's figures (398,000) were but slightly higher than those of the year before, and this year's returns to the end of May show a distinct falling off from the same period last year (155,000 against 186,000). The majority of those "emigrants" are of British or Irish origin. But a large proportion are foreigners, who use the route *viâ* the United Kingdom to foreign parts. The crosses in our diagram indicate the numbers of our own people for a few years. Last year there were 279,000 out of 398,000, the rest being foreigners.

How is the stream of emigration distributed? Most goes to the United States, of course; they had about 70 per cent. last year (the number being 293,000, which is slightly less than the year before). The curves for British North America and Australasia cross and recross, now the one country, now the other, gaining a preponderance. At present British North America is in the ascendant, and its curve is tending upwards, while that of Australasia is tending downwards. Last year the former had about 13 per cent. of the emigrants, the latter about 11. The recent rise in the curve of all other places (given in part only) is probably connected, in part, with the gold discoveries in the Transvaal. Emigration to Central and South America is also increasing. The total number of immigrants from those same countries last year was about 128,000. Note how the curve of immigrants (the upper dotted one) somewhat corresponds with, but lags in its phases behind, the emigrants' curve.

In our second diagram we show how the English, Irish, and Scotch elements have varied in proportion of the totals



2. Percentages of English, Scotch, and Irish Emigrants

of our people emigrating. The English last year were 61 per cent. of the whole, the Irish 26 (as against 37 at the outset), and the Scotch 13. There was a large increase of Irish emigration in 1880, the percentage reaching 41 (1879 was a memorably bad year in Ireland); but since then, it will be seen, the proportion has been going down. The Scotch, on the other hand, have been growing in proportion since 1884.

It is a curious fact that while the English and Scotch adult male emigrants are very much in excess of the females, sometimes nearly twice as many, and the foreign (adult males) more than twice as many, the Irish males and females are nearly equal in number; in some recent years there has even been a small excess of females. The Scotch

emigrants include the highest proportion of children (22 per cent. last year), the Irish the least (10·8 per cent.). The great bulk of the English emigration is from Liverpool, that of the Scotch from Glasgow and Greenock, that of the Irish from Queenstown. Of the adults emigrating last year, some 80,000 are described as "general labourers," 29,000 (female) "domestic and farm servants, nurses, &c.," 24,000 "agricultural labourers, gardeners, carters, &c.," 20,000 "mechanics," 14,000 "gentlemen, professional men, merchants, &c.," 11,000 "farmers and graziers," 5,000 "miners and quarrymen," 3,000 "clerks and agents," 3,000 "shopkeepers," and so on.

GROWTH AND DECAY OF MIND.

By THE LATE R. A. PROCTOR.

And so from hour to hour we ripe and ripe,
And then from hour to hour we rot and rot,
And thereby hangs a tale.—*As You Like It.*

FEW subjects of scientific investigation are more interesting than the inquiry into the various circumstances on which mental power depends. By mental power I do not mean simply mental capacity, or the potential quality of the mind, but the actual power which is the resultant, so to speak, of mental capacity and mental training. The growth and development of mental power in the individual, and the process by which, after attaining a maximum of power, the mind gradually becomes less active, until in the course of time it undergoes at least a partial decay, form the special subjects of which I propose now to treat; but in order to form clear ideas on these subjects it will be necessary to consider several associated matters. In particular, it will be desirable to trace the analogy which exists between bodily and mental power, not only as respects development and decay, but with regard to the physical processes involved in their exercise.

It is now a well-established physiological fact that mental action is a distinctly physical process, depending primarily on a chemical reaction between the blood and the brain, precisely as muscular action depends primarily on a chemical reaction between the blood and the muscular tissues. Without the free circulation of blood in the brain there can be neither thought nor sensation, neither emotions nor ideas. It necessarily follows that thought, the only form of brain action which we have here to consider, is a process not merely depending upon, but in its turn affecting, the physical condition of the brain, precisely as muscular exertion of any given kind depends on the quality of the muscles employed and affects the condition of those muscles, not at the moment only, but thereafter, conducing to their growth and development if wisely adjusted to their power, or causing waste and decay if excessive and too long continued. It is important to notice that this is not a mere analogy. The relation between thought and the condition of the brain is a reality. So far as this statement affects our ideas about actually existent mental power, it is of little importance; for it is not more useful to announce that a man with a good brain will possess good mental powers than to say that a muscular man will be capable of considerable exertion. But as it is of extreme importance to know of the relation which exists between muscular exercise and the growth or development of bodily strength, so it is highly important for us to remember that the development of mental power depends largely on the exercise of the mind. There is a "training" for the brain as well as for the body—a real physical training —depending, like bodily training, on rules as to nourishment, method of action, quantity of exercise, and so forth.

When we thus view the matter, we at once recognise the significance of relations formerly regarded as mere analogies between mental and bodily power. Instead of saying that as the body fails of its fair growth and development if overtaxed in early youth, *so* the mind suffers by the attempt to force it into precocious activity, we should now say that the mind suffers in this case in the same actual manner—that is, by the physical deterioration of the material in and through which it acts. Again, the old adage, "mens sana in corpore sano," only needs to be changed into "cerebrum sanum in corpore sano," to express an actual physical reality. The processes by which the brain and the body are nourished, as well as those which produce gradual exhaustion when either is employed for a long time or on arduous work, not only correspond with each other, but are in fact identical in their nature; so that Jeremy Taylor anticipated a comparatively recent scientific discovery when he associated mental and bodily action in the well-known apophthegm, "Every meal is a rescue from one death and lays up for another; and while we think a thought we die." This is true, as Wendell Holmes well remarks, "of the brain as of other organs: the brain can only live by dying. We must all be born again, atom by atom, from hour to hour, or perish all at once beyond repair."

And here it is desirable to explain distinctly that the relations between mind and matter which we are considering are not necessarily connected with any views respecting the questions which have been at issue between materialism and its opponents. We are dealing here with the instrument of thought, not with *that*, whatever it may be, which sets the instrument in motion and regulates its operation. So far indeed as there is any connection between physical researches into the nature of the brain or its employment in thought, and our ideas respecting the individuality of the thinker, the evidence seems not of a nature to alarm even the most cautious. Thus when Huxley maintains that thought is "the expression of molecular changes in that matter of life which is the source of our other vital phenomena," we are still as far as ever from knowing where resides the moving cause to which these changes are due. We have found that the instrument of thought is moved by certain material connecting links before unrecognised; but to conclude that therefore thought is a purely material process, is no more necessarily just than it would be to conclude that the action of a steam-engine depends solely on the eccentric which causes the alternation of the steam-supply. Again, we need find nothing very venturesome in Professor Haughton's idea, that "our successors may even dare to speculate on the changes that converted a crust of bread, or a bottle of wine, in the brain of Swift, Molière, or Shakspeare, into the conception of the gentle Glumdalclitch, the rascally Sganarelle, or the immortal Falstaff," seeing that it would still remain unexplained how such varying results may arise from the same material processes, or how the selfsame fuel may produce no recognisable mental results. The brain does not show in its constitution why such differences should exist. "The lout who lies stretched on the tavern-bench," says Wendell Holmes, "with just mental activity enough to keep his pipe from going out, is the unconscious tenant of a laboratory where such combinations are being constantly made as never Wöhler or Berthelot could put together: where such fabrics are woven, such colours dyed, such problems of mechanism solved, such a commerce carried on with the elements and forces of the outer universe, that the industries of all the factories and trading establishments in the world are mere indolence, and awkwardness, and unproductiveness, compared to the miraculous activities of which his lazy bulk is the unheeding centre." Yet the conscious thought of the

lout remains as unlike as possible to the conscious thought of the philosopher; nor will crusts of bread or bottles of wine educe aught from the lout's brain that men will think worth remembering in future ages.

Moreover, we must remember that we have to deal with facts, let the interpretation of these facts be what it may. The relations between mental activity and material processes affecting the substance of the brain are matters of observation and experiment. We may estimate the importance of such research with direct reference to the brain as the instrument of thought, without inquiring by what processes that instrument is called into action. "The piano which the master touches," to quote yet again from the philosophic pages of Holmes's "Mechanism in Thought and Morals," "must be as thoroughly understood as the musical box or clock which goes of itself by a spring or weight. A slight congestion or softening of the brain shows the least materialistic of philosophers that he must recognise the strict dependence of mind upon its organ in the only condition of life with which we are experimentally acquainted; and what all recognise as soon as disease forces it upon their attention, all thinkers should recognise without waiting for such an irresistible demonstration. They should see that the study of the organ of thought, microscopically, chemically, experimentally, in the lower animals, in individuals and race, in health and in disease, in every aspect of external observation, as well as by internal consciousness, is just as necessary as if the mind were known to be nothing more than a function of the brain, in the same way as digestion of the stomach."

In considering here, however, the growth of the mind, it appears to me sufficient to call attention to the physical aspect of the subject, without entering into an account of what is known about the physical structure of the brain and the manner in which that structure is modified with advancing years. Moreover, I do not think it desirable, in the limited space available for such an essay as the present, to discuss the various forms of mental power; indeed, this is by no means essential where a general view of mental growth and decay is alone in question. Precisely as we can consider the development and decay of the bodily power without entering into a discussion of the various forms in which that power may be manifested, so we can discuss the growth of the mind without considering special forms of mental action.

Nevertheless, we cannot altogether avoid such considerations, simply because we must adopt some rule for determining how to know when mental power is growing. Here, indeed, at the outset, a serious difficulty is encountered. Certain signs of mental decay are sufficiently obvious, but the signs which mark the progress of the mind to its maximum degree of power, as well as the earlier signs of gradually diminishing mental power, are far more difficult of recognition. This is manifest when we consider that they should be more obvious, one would suppose, to the person whose mind is in question than to any other; whereas it is a known fact that men do not readily perceive (certainly are not ready to admit) any falling off in mental power, even when it has become very marked to others. "I, the Professor," says Wendell Holmes in the "Professor at the Breakfast-table," "am very much like other men. I shall not find out when I have used up my affinities. What a blessed thing it is that Nature, when she invented, manufactured, and patented her authors, contrived to make critics out of the chips that were left! Painful as the task is, they never fail to warn the author, in the most impressive manner, of the probabilities of failure in what he has undertaken. Sad as the necessity is to their delicate sensibilities, they never hesitate to advertise him of the decline of his powers, and to press upon him the propriety of retiring before he sinks into imbecility." Notwithstanding the irony, which is just enough so far as it relates to ordinary criticism, there can be no question that when an author's powers are failing, his readers, and especially those who have been his most faithful followers, so to speak, devouring each of his works as it issues from his pen, begin to recognise the decrease of his powers before he is himself conscious that he is losing strength. The case of Scott may be cited as a sufficient illustration, its importance in this respect being derived from the fact that he had long been warmly admired and enthusiastically appreciated by those who at once recognised signs of deterioration in "Count Robert of Paris" and "Castle Dangerous."

Yet judgment is most difficult in such matters. We can readily see why no man should be skilled to detect the signs of change in his own mind, since the self-watching of the growth and decay of mind is an experiment which can be conducted but once, and which is completed only when the mind no longer has the power of grasping all the observed facts and forming a sound opinion upon them. But it is even more natural that those who follow the career of some great mind should often be misled in their judgment as to its varying power. For it must be remembered that the conditions under which such minds are exercised nearly always vary greatly as time proceeds. This circumstance affects chiefly the correctness of ideas formed as to the decay of mental powers, but it has its bearing also on the supposed increase of these powers. For instance, the earlier works of a young author, diffident perhaps of his strength or not quite conscious where his chief strength resides, will often be characterised by a weakness which is in no true sense indicative of want of mental power. A work by the same author when he has made for himself a name, when he knows something of the feeling of the public as to his powers, and when also he has learned to distinguish the qualities he possesses—to see where he is strong and where weak—will have an air of strength and firmness not due, or only partially due, to any real growth of his mental powers. But as I have said, and as experience has repeatedly shown, it is in opinions formed as to the diminution of mental power that the world is most apt to be deceived. How commonly the remark is heard that So-and-so has written himself out, or Such-a-one is not the man he was, when in reality, as those know who are intimate with the author so summarily dismissed, the deterioration justly enough noted is due to circumstances in no way connected with mental capacity. The author who has succeeded in establishing a reputation may not have (nay, very commonly has not) the same reason for exerting his powers to the full, as he had when he was making his reputation. He may have less leisure, more company, new sources of distraction, and so on. The earlier work, his *chef-d'œuvre*, let us say, may have been produced at one great effort, no other subject being allowed to occupy his attention until the masterpiece had been completed—the later and inferior work, hastily accepted as evidence that the author's mind no longer preserves its wonted powers, may have been written hurriedly and piecemeal, and subjected to no jealous revision before passing through the press.

(*To be continued.*)

Sand Grouse in Yorkshire.—Four sand grouse were seen as lately as the middle of June in a cornfield on the edge of Manshead Moor, about four miles south-east of Todmorden, and all of them—two males and two females—were wantonly shot. The place where they were killed is about 900 feet above the sea-level. We may mention that the gradual elevation above the sea that has been recorded for sand grouse in this country is 1,200 feet.—*The Zoologist.*

A History of the Study of Mathematics at Cambridge. By W. W. Rouse Ball, Fellow and Lecturer of Trinity College, Cambridge. University Press. 1889.)—This is a most interesting little book, containing in its 260 small 8vo. pages an immense amount of information with respect to life at the university in the Middle Ages, and other matters which only bear incidentally on the study of mathematics. The book is only too much compressed, one would continually like to be asking its author for further information which he must possess in order to be able to give the many general summaries of facts for which the book is remarkable. Here is an example: "The hour of dining gradually grew later. In 1570 it was at 9.0, or at Trinity at 10.0. By 1755 it had got shifted to noon. In 1800 it was at 2.15 at Trinity, and at 1.30 at most other colleges, and the senior members of the university began to complain that the afternoon attendance at the schools was in consequence much diminished. A few years later dinner was usually served at 3.0, but until 1850 the hour did not, I think, get later than 5.0. Since then the same movement has gone on, and now (1889) dinner at Trinity is at 7.30." Sir Isaac Newton is much too summarily dealt with, and the controversy with Leibnitz is dismissed thus:—"From what I have read of the voluminous literature on the question, I think, on the whole, it points to the fact that Leibnitz obtained the idea of the differential calculus from a manuscript of Newton's which he saw in 1673." A judgment with which Professor de Morgan certainly would not have concurred. One would like to know to what Mr. Ball refers when he says of Newton, "During the early half of his life he was parsimonious, if not stingy, and he was never liberal in money matters." It is true that during the early and brilliantly fruitful part of his life he was poor, but he was certainly not mean either to his cousin or to his mother. Sir David Brewster gives many stories (some perhaps doubtful) of his freehandedness in money matters in after life. The book is one for reference, and fortunately Mr. Ball has provided his readers with an excellent index.

A USEFUL CEMENT.

The following mixture has been used with the greatest possible success for the cementing of iron railing tops, iron gratings to stoves, &c.: in fact, with such effect as to resist the blows of a sledge-hammer. This mixture is composed of equal parts of sulphur and white lead, with about one-sixth proportion of borax, the three being thoroughly incorporated together so as to form one homogeneous mass. When the application is to be made of this composition, it is wet with strong sulphuric acid, and a thin layer of it is placed between the two pieces of iron, these being at once pressed together. In five days it will be perfectly dry, all traces of the cement having vanished, and the work having every appearance of welding.—*The American Artisan.*

Letters.

The Editor does not hold himself responsible for the opinions or statements of correspondents.]

PHOTOGRAPHS OF LIGHTNING.

To the Editor of Knowledge.

Dear Sir,—I was much interested by the article in the July number of Knowledge on lightning photographs. I think none of the conjectures hit the nail on the head. When I saw Mr. Shepherd's dark flash in the Photographic Exhibition nearly two years ago, at the first moment I thought of solarisation, but that was immediately negatived by the consideration that on that supposition the edges ought to be light. It then occurred to me—and I mentioned it to one of the photographers as I went out—that a flash had struck very shortly before the camera had been uncapped, and had left a tube of air containing nitrous acid gas in its path, and that a subsequent flash illuminated the cloud behind, and where the dispersed light on its way to the camera had to pass through the tube the actinic rays were absorbed. Till about a month ago I thought that this was the true theory, though six or seven weeks ago I received an experimental photograph from Mr. Wimshurst that was puzzling on this view, and I suggested some experiments further to test the view. But after the delivery of the Rede lecture on June 12 my friend the Rev. G. B. Atkinson showed me a photograph obtained by him in the great thunderstorm of June 6, which showed me that the absorption theory could not be maintained. The action must be direct; and I thought the result would be accounted for by the known undoing action of the less refrangible rays. An explanation pointing in the same direction has been brought before the Physical Society by Mr. Clayden, who has since obtained some remarkable experimental results. The experiments are in progress.—Yours very truly, G. G. Stokes.

Lensfield Cottage, Cambridge: July 10, 1889.

DARK LIGHTNING FLASHES.

To the Editor of Knowledge.

Sir,—I notice that you have recently devoted very considerable space to the discussion of the various phenomena exhibited in photographs of lightning. Among these the most obscure is probably the existence of dark images, the so-called dark flashes, and a variety of different theories have been brought forward in the attempt to explain them. It so happened that I was fortunate enough to secure an example of such images among some photographs which I took during the storm on June 6. From certain observations in connection with this plate I was led on to some experiments which I think sufficiently prove that dark flashes are merely a photographic effect produced by the subsequent, or possibly simultaneous, illumination of the clouds.

I have already described some of these experiments in a short note read before the Physical Society, but as that account may not meet the eye of some of your readers, perhaps it may be of interest to describe them again. My dark-flash plate shows four of the dark images and one bright one, as well as another faint but normal image. I felt certain that a particularly fine flash had impressed itself nearly vertically down the middle of the plate, which was exposed altogether to six flashes, and to the diffused light from several others which were either hidden in the clouds or else were out of the field of view.

When I came to develope the plate I at once found that it was greatly over-exposed, and had to treat it very carefully. I was much surprised to find only one triple flash in the corner. The fine vertical flash seemed to be absent; but on inspecting the plate after fixing, I discovered that its image was reversed. Yet the reversal was not complete. Three flashes printed quite dark, so did the branches and upper portion of the vertical one; but the lower part of its main stem (if such a phrase is allowable) showed an unreversed core. Now it was evident that the reversal was due in some way or other to the fact that the plate had been exposed too long. Other photographs taken on the same evening showed no such effect, and they were exposed much less. Hence I conceived that it ought to be possible to

reproduce the phenomenon in photographs of electric sparks.

The first experiment was to photograph a large number of sparks in a dark room on the same plate, but although the images crossed and recrossed each other in all directions there was no indication of reversal. Each spark gave a clear image standing out boldly on the dark background, and points of crossing were even extra bright.

The second was to allow the images of a series of bright sparks from large Leyden jars to impress themselves across the plate. It was then removed from the camera and exposed to diffused gaslight, so that different portions were acted upon for different lengths of time. On developing it was seen (fig. 1)* that the images of the sparks were bright, with a

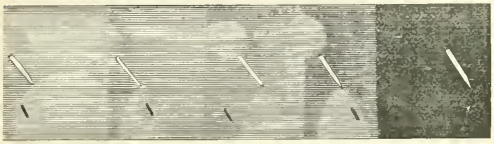


Fig. 1.

dark margin (I speak always of the print obtained), and that this dark margin spread inwards towards the centre as the duration of the exposure to gaslight increased.

Next, I took a series of somewhat less brillant sparks, and exposed half the plate to gaslight for a second. The sparks came out bright on the part not exposed to gaslight, and reversed on the other (fig. 2). It was thus evident that a

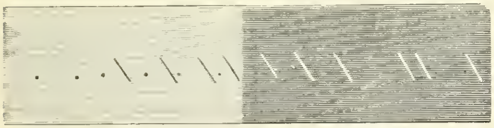


Fig. 2.

reversal was easily produced by subsequent general exposure, but the next point was to suggest how that subsequent effect could be produced in nature.

Of course my first experiment did not correctly represent what occurs during a thunderstorm. My sparks were projected upon a dark background. Lightning flashes have masses of white clouds behind them. Hence I photographed a number of sparks, after having previously placed a sheet of white card behind the terminals in order to imitate the cloud. Some of the earlier sparks showed reversal, and and others exhibited marginal reversal with the white core already remarked upon (fig. 3).

Fig. 3.

This experiment seemed almost conclusive, and, after repeating the whole series to confirm the results, I felt assured that I had found the clue to the mystery of dark flashes.

Since then I have pursued the subject further through a long series of experiments which I propose to publish in due time. Meanwhile I may say that I have abundant evidence to show that the reversal of the images is due to subsequent exposure to diffused light, which is apparently powerless to reverse subsequent images. I have therefore had no difficulty whatever in imitating all the observed phenomena, such as the crossing of a dark image by bright ones. From a meteorological point of view this is sufficient. Dark flashes have no existence in nature. They are not even due to any peculiarity of lightning discharges, such as an oscillatory series of flashes. They are a purely photographic effect, the explanation of which belongs to the most obscure portion of the physics of photography. I do not attempt even to suggest a theory at present, but I hope that my experiments, some of which have been kindly suggested to me by Sir G. G. Stokes, will at any rate provide a good deal of material for future elucidation.

In conclusion, allow me to apologise for trespassing so largely on your valuable space.—Yours very truly,

Arthur W. Clayden.

Warleigh, Palace Road, S.W. :
July 19, 1889.

* The woodcuts illustrating this letter have been kindly lent by the Editor of the *Electrician*, in which a short report of Mr. Clayden's paper read before the Physical Society was printed.—Editor.

PHOTOGRAPHS OF THE ORION NEBULA.

To the Editor of Knowledge.

Dear Sir,—I have examined Professor Pickering's lantern slide of the Orion Nebula referred to in his letter in the July number of Knowledge. I infer that this slide represents some of his best work. If so, I cannot trace any nebulosity connecting together the three nebulæ (M 42, M 43, and h 1180) upon it. There is more shown upon my early photograph of November 1886 than can be seen upon this slide, but there is a noticeable light patch to the north following of M 43, which looks like, and has possibly been, assumed by Professor Pickering to be a nebulosity joining the two nebulæ. A comparison with my negatives, however, shows that it is really a photographic defect or stain on the film. That this is the case is proved by the fact that I can only count twenty-two stars on Professor Pickering's photograph within a circle which is described so as to contain the nearest margins of M 43 and h 1180, and includes the area of the connecting nebulosity, while on my photograph I counted within a similar area (taking into account of course the difference of scale) fifty-four stars. I am unable to judge what may be seen on Professor Pickering's original negative; but, on the other hand, he cannot judge of what can be seen on mine from the enlargements published in Knowledge. All negatives lose greatly by copying. I await with interest the publication of Professor Pickering's promised paper.—Yours faithfully,

Isaac Roberts.

Kenuessee Maghull, near Liverpool:
July 11, 1889.

To the Editor of Knowledge.

Sir,—Some twenty years ago I noticed a curious phenomenon in the case of a large family with which I was intimately acquainted, namely, that the eldest child resembled closely in appearance, manner, and disposition the maternal parent; the second eldest bore the same close resemblance to the father; the third, again, resembled the mother, and so on through the whole family. It struck me

that this alternate resemblance to male and female parent (the eldest always resembling the mother) might possibly have a wider application than the limits of this particular family, and ever since that time I have taken every opportunity of putting the matter to the test. Though every case did not exhibit the phenomenon so strikingly as the first one observed (in which the great difference in the mental and physical development of the male and female parent was very marked), yet, on the whole, the results of all subsequent observations have tended to confirm my original impression. Perhaps you, or some of your readers who take an interest in such subjects, might think the matter worthy of notice.—Your obedient servant,

FRANCIS HERON
(Demonstrator R. Coll. Surgeons).

Royal College of Surgeons, Dublin:
July 13, 1889.

SOME PROPERTIES OF NUMBERS.

By ROBERT W. D. CHRISTIE, M.A.

I. (1) BY Pollock's Theorems every odd number may be divided into four squares in four different forms, the algebraic sums of whose roots may equal 1, 3, 5 . . . $2n-1$ up to the maximum, *e.g.*, $73=4^2+4^2+4^2+5^2=2^2+2^2+4^2+7^2=0^2+1^2+6^2+6^2=1^2+2^2+2^2+8^2$. Here the sums of the roots are respectively 17 (the maximum) 15, 13 and 13. By changing the signs of one or more of the roots we may make the sums of the roots equal to any odd number from 1 to 17 inclusive. Thus *e.g.* $73=(-1)^2+2^2+2^2+8^2$ and the sums of the roots $=11=(-1)+2+2+8$, &c.

Lagrange and others have demonstrated that primes of the Form $4N+1$ may be divided into two different integral square numbers, *e.g.*, $5=1^2+2^2$; $13=2^2+3^2$, &c. I have extended this well known theorem as follows:—

$(r^2+1)^m(4N+1)=$ two integral squares where m and r may be any integers whatever. Thus, *e.g.*, let $m=2$, $r=2$.

Then $(2^2+1)^2\times 29=25\times 29=7^2+26^2$.

And since every even square greater than 5 may be divided into four $4N+1$ primes, we can thus resolve any even square into *sixteen* squares by Pollock's, or into *eight* different squares by Lagrange's Theorem, *e.g.*, $18^2=37+41+97+149=41+61+73+149=41+53+73+157=41+73+97+113=41+73+101+109$, &c., &c., and each of these primes may be split up into four or into two different squares *ad libitum*. Thus, *e.g.*, $10^2=13+17+29+41=(2^2+3^2)+(1^2+4^2)+(2^2+5^2)+(4^2+5^2)$ by Lagrange $=16$ squares by Pollock, since 13, 17, 29, & 41 are odd primes.

(2) By means of the Diophantine Analysis it is easy to show that if $N=a^2+b^3$, it also equals $[\{2mnb+(n^2-m^2)a\}/(m^2+n^2)]^2+[\{2mna+(m^2-n^2)b\}/(m^2+n^2)]^2$, where m and n may be assumed at pleasure. Thus, *e.g.*, if $m=2$, $n=1$, we may say $13=2^2+3^2=(\frac{6}{5})^2+(\frac{17}{5})^2$, and so on.

By combining (1) with (2) we can thus split up any prime of Form $4N+1$ into as many pairs of squares as we think proper. Thus, *e.g.*, $6^2=1+5+13+17=1^2+1^2+2^2+2^2+3^2+1^2+4^2$, &c., &c.

If we wish to divide any square number into two other square integers, the following is a convenient equation for our purpose:—$\{2r^2+(2n+1)2r+4n^2+1\}^2\equiv\{2r^2+2r(2n+1)+4n\}^2+\{(2n-1)(2r+2n+1)\}^2$, where n and r may be any integers. Thus, *e.g.*, if $r=3$, $n=2$, we have $65^2=56^2+33^2$. It may be incidentally mentioned that *one* of the three squares is always divisible by 5.

(3) Mainly from the simple fact that $2+2\equiv 2\times 2$ I have constructed an interesting theorem, which will enable us to turn n integral squares into n other integral squares in $n+1$ different ways. $(na_1^m)^2+(na_2^m)^2+(na_3^m)^2 \;.\;.\;.\; (na_r^m)^2\equiv\{2(a_1^m+a_2^m \;.\;.\;.\; a_{r-1}^m)-(n-2)a_r^m\}^2+n-1$ corresponding symmetrical expressions, *e.g.*; let $n=3$ $m=1$, then we have $(3a_1)^2+(3a_2)^2+(3a_3)^2\equiv(2a_1+2a_2-a_3)^2+(2a_2+2a_3-a_1)^3+(2a_3+2a_1-a_2)^2\equiv(-2a_1+2a_2-a_3)^2+(2a_2+2a_3+a_1)^2+(2a_3-2a_1-a_2)^2\equiv(2a_1-2a_2-a_3)^2+(-2a_2+2a_3-a_1)^2+(2a_3+2a_1+a_2)^2\equiv(2a_1+2a_2+a_3)^2+(2a_2-2a_3-a_1)^2+(-2a_5+2a_1-a_2)^2$.

If integers be desired, let $a_1=2$ $a_2=5$ $a_3=11$, say, and we have at once $6^2+15^2+33^2=3^2+30^2+21^2=5^2+34^2+13^2=17^2+10^2+31^2=25^2+14^2+23^2$. And since the sum of the roots of the first three (or n) squares always equals the sum of the second three (or n) squares, we can raise or depress the equations *ad libitum*. Thus, *e.g.*, instead of $6^2+15^2+33^2=3^2+30^2+21^2$, we may add or subtract any number from each member of the equation without vitiating it. Thus, *e.g.*, we may write down at once $7^2+16^2+34^2=4^2+31^2+22^2$ or $5^2+14^2+32^2=2^2+29^2+20^2$, and so on.

(4) In order to obtain a square number equal to n other square numbers, we have $U^2\equiv A_1^2+A_2^2 \;.\;.\;.\; A_n^2$, if $A_1=a_1^2+a_2^2$——— a_n^2, and $A_2=2a_1a_n$, $A_3=2a_2a_n$ . . . $A_n=2a_{n-1}a_n$. *E.g.*, suppose we want a square number equal to *seven* other square numbers:—

Let $a_1=1$ $a_2=3$ $a_3=5$ $a_4=7$ $a_5=2$ $a_6=4$ $a_n=8$, say.

Then $A_1=40$ $A_2=16$ $A_3=48$ $A_4=80$ $A_5=112$ $A_6=32$ $A_7=64$. Thus, after cancellation, $21^2=5^2+2^2+6^2+10^2+14^2+4^2+8^2$.

II. A perfect number is one which is equal to the sum of all the lesser numbers which divide it without remainder. These numbers have engaged the attention of mathematicians from very early times. Euclid treats of them in the last proposition of his Ninth Book. No odd perfect number has yet been discovered, and the most eminent mathematicians are at variance on the point. Descartes in 1638 wrote:—"Je juge qu'on peut trouver des nombres impairs véritablement parfaits." On the other hand, Professor Sylvester says, December 15, 1887:—"There seems every reason to believe that Euclid's Perfect Numbers are the only perfect numbers which exist." The formula for a perfect number is $P=2^n(2^{n+1}-1)$ provided $2^{n+1}-1$ be a prime, i.e., provided $n+1$ be a (not *any*) prime. If we could solve the problem "What prime p will make 2^p-1 a prime," there would be little difficulty in obtaining any number of perfect numbers, but as it is, only about a dozen perfect numbers are known.

The first six perfects are 6, 28, 496, 8128, 33550336, 8589869056. Thus, *e.g.*, the factors of 6 are 1, 2, 3, and $1+2+3=6$. Therefore 6 is a perfect number. Again, the factors of 28 are 1, 2, 4, 7, 14, and $1+2+4+7+14=28$. Thus 28 is also a perfect number, and so on with the others. From the above formula for perfects we make the following deductions:—

(1) Every perfect number equals a sequence from unity but from no other number.

(2) Perfects are all of Form $9N+1$ (except the first).

(3) They must end in the digits 6 or 8.

(4) The product of the factors of a Perfect number is an exact power of the Perfect itself, i.e. Product of Factors $\equiv P^n\equiv\{2^n(2^{n+1}-1)\}^n$.

(5) The number of positive integers less than the Perfect and prime to it divided by the Perfect is less than one-half or $\phi(P)/P<\frac{1}{2}$.

(6) Every perfect number except the first equals an *even* number of *odd* cubes, e.g. $28=1^3+3^3$; also $496=1^3+3^3+5^3+7^3$; also Product of Factors of $28=1\times 2\times 4\times 7\times 14=784=28^2$ (*v.* No. (4) above).

(7) If P=any perfect number and p any prime number (except 5), then $(P^4 \sim p^4)/5$ is always an integer.

Many other interesting deductions may be drawn.

Secondary Perfects are as difficult to obtain as the primary. The following are all I have been able to obtain easily: $P_2 = 2^5.3.7 = 672$. $P_2 = 2^9.3.11.31 = 523776$, $P_2 = 2^{13}.3.11.43.127.$, $P_2 = 2^8.5.7.19.37.73$. This means that the sum of the factors of 672 equals twice the number itself, thus e.g. the sum of

1,2,3,4,6,7,8,12,14,16,21,24,28,32,42,48,56,84,96,112,168, 224,336=2×672. Some Perfects the sum of whose factors equals three times the Perfect itself are: $P_3 = 2^5.3^3.5.7$; $P_3 = 2^8.3.5.7.19.37.73$; $P_3 = 2^7.3^6.5.17.23.137.547.1093$.

III. A pretty theorem of Sylvester's is as follows. Every number may be resolved into a sequence in as many ways as it contains odd factors; *e.g.*, 63 has 6 odd factors, viz., 1, 3, 7, 9, 21, 63, and therefore it may be represented by the *six* following sequences and no others:—$63=31+32=20+21+22=8+9+10+11+12+13=6+7+8+9+10+11+12=3+4+5+6+7+8+9+10+11$. On similar principles we are able to deduce that n^m is the sum of n consecutive odd numbers; *e.g.*, $4^3=13+15+17+19$. Or again, n^m equals a sequence of n natural numbers if n be odd and m greater than unity. Thus, *e.g.*,

$$5^2=3+4+5+6+7.$$

IV. We may form squares by means of cubes in various ways. One well-known equation is $\Sigma^3_n \equiv (\Sigma^1_n)^2$. This means that if we take any number of successive cubes from unity their sum is always a square; *e.g.*, $1^3+2^3+3^3+4^3+5^3=(1+2+3+4+5)^2=15^2$.

Another equation is $\Sigma^3+(2\Sigma^1)^3=(3\Sigma^2)^2$; *e.g.*, $n=4$ gives us $1^3+2^3+3^3+4^3+\{2(1+2+3+4)\}^3 = \{3(1^2+2^2+3^2+4^2)\}^2=90^2$.

Again, $1^3+3^3+5^3 \text{——} +(2n-1)^3=(n\mathrm{M})^2$ where n is the denominator and M the numerator of any odd convergent of $\sqrt{2}$; *e.g.*, $n=5$ M=7, then $1^3+3^3+5^3+7^3+9^3=(1+3+5+7+9)(7^2)=35^2$.

While we are dealing with series, the following equations will, I think, be found interesting:—$S_5+S_7=2S_3{}^2$. Thus $n=3$ gives us $1^5+2^5+3^5+1^7+2^7+3^7=2\{(1^3+2^3+3^3)\}^2$. Other equally pretty equations are:—$7S_6+5S_4=12S_2S_3$ $(3S_5+2S_1^3)_5/5S_4=S_3/S_2$, &c. Thus if we suppose $n=2$, we have

$$7(1^6+2^6)+5(1^4+2^4)=12(1^2+2^2)\times(1^3+2^3)$$
$$i.e., \quad 7\times65+5\times17 \quad =12\times5\times9, \text{ or } 540=540.$$

Again, for the other equation let $n=3$, and we get

$$3(1^5+2^5+3^5)+2(1+2+3^3)\div5(1^4+2^4+3^4)=(1^5+2^3+3^3)\div(1^2+2^2+3^2)$$
$$i.e., \quad 3+276+2\times216 \quad \div5+98 \quad =26\div14$$
$$\text{or} \quad 1260 \quad \div490 \quad =36\div14,$$

which is true, and so on for all values of n.

V. It is impossible to find any two cubes, whose sum or difference is a cube, or even twice a cube, but there are various ways of resolving a cube into three cubes. Euler's well-known formula is somewhat elaborate. One of the simplest is—

$$\{b(b^3+2a^3)\}^3 \equiv \{a(b^3-a^3)\}^3+\{b(b^3-a^3)\}^3+\{a(2b^3+a^3)\}^3,$$

where a and b may be any integers whatever.

To get the sum of three cubes into three other cubes, a simple formula is $(3p^2-q^2)^3+(p^2+q^2+4pq)^3+(p^2+q^2-4pq)^3 \equiv (p^2+q^2)^3+(3p^2+3q^2)^3+(p^2-3q^2)^3$, a formula which may be generalised—Here p and q may be any integers.

Let $p=5$, $q=3$, then $(3\times5^2-3^2)^3+(5^2+3^2+4\times5\times3)^3+(5^2+3^2-4\times5\times3)^3=(5^2+3^2)^3+3(5^2+3^2)+5^2-3\times3^2)^3$. Thus, after dividing by 2, we get

$$1^3+33^3+17^3=13^3+17^3+51^3,$$

and similarly for all values of p and q.

We can resolve a cube into a number of squares.

Let $x=p^3-3pq^2$, $y=3p^2q-q^3$.

Then

$$x^2+y^2=(p^2+q^2)^3=\{p(p^2+q^2)\}^2+\{q(p^2+q^2)\}^2;$$

and generally

$$(p^2+q^2+r^2 \text{——} +z^2)^3=\{p(p^2+q^2 \text{——} +z^2)\}^2 + \{q(p^2+q^2 \text{——} z^2)\}^2+\{r(p^2+q^2 \text{——} +z^2)\}^2+\&c.$$

Thus, if $p=3$, $q=2$, $r=1$, we get

$$(3^2+2^2+1^2)^3=\{3(3^2+2^2+1^2)\}^2+\{2(3^2+2^2+1^2)\}^2 + \{1(3^2+2^2+1^2)\}2, \text{ or } 14^3=42^2+28^2+14^2.$$

We can resolve a number into three cubes. Let $n=$ the number. Assume $n^3=(n-bx)^3+(cx+1)^3+(dx-1)^3$, and make $b=(c+d)/n^2$.

Then $x=\{3(d^2-c^2-nb^2)/(d^3+c^3-b^3)\}$;

e.g. $n=2$, $b=3$, $c=7$, $d=5$.

Then $x=-\frac{2}{7}$, and $20^3=7^3+14^3+17^3$.

If $b=c$, then $3^3+4^3+5^3=6^3$.

If $b=d$, then $18^3+19^3+21^3=28^3$;

$c=d$, gives us $9^3+10^3=1^3+12^3$, &c. &c.

THE FACE OF THE SKY FOR AUGUST.

By Herbert Sadler, F.R.A.S.

SPOTS on the solar surface are becoming rather more frequent, but there have not been many of any considerable size as yet. Conveniently observable minima of Algol occur on the 4th at 10h. 39m. P.M., and on the 27th at 9h. 10m. P.M. The variable star o (Mira) Ceti will arrive at a maximum on the 6th. Mercury comes into superior conjunction with the sun on the 7th, and is practically invisible throughout the month. Venus is a morning star, rising on the 1st at 1h. A.M., with a northern declination of 20° 51′, and an apparent diameter of $18\frac{1}{2}''$. On the last day of the month she rises at 1h. 30m. A.M., her declination having decreased to $19\frac{1}{2}°$, and her diameter to 15″. She passes from Orion through Gemini into Cancer. At about 4h. A.M. on the 18th she will be 26′ due north of the 4th magnitude star ζ Geminorum. Mars is actually a morning star, as he rises on the 1st at 3h. 6m. A.M., and on the 31st at 2h. 58m. A.M., but his diameter does not exceed $4\frac{1}{2}''$ during the month, so that he is practically not worth looking at with a telescope. His path throughout the month is in Cancer. Saturn is invisible, being in conjunction with the sun on the 16th. Jupiter is visible during all the working hours of the night, but owing to his great southern declination is very unfavourably suited for observation. He rises on the 1st at 5h. 20m. P.M. with a southern declination of 23° 22′, and an apparent diameter of $44\frac{1}{2}''$, and on the 31st at 3h. 17m. P.M., with an apparent diameter of 41″. He is nearly stationary throughout the month in Sagittarius, and during the last fortnight will be found about 23′ nearly due north of the $5\frac{1}{2}$ magnitude star 4 Sagittarii. On the evenings of the 1st and 2nd a 9th magnitude star will be seen a little to the north of the planet and its satellites. To his occultation by the moon on the 7th we allude below. The following phenomena of the satellites occur between the times of the planets' being 8° above the horizon, and the sun's being 8° below, on the days named. On the 4th an egress from transit of the third satellite at 10h. 49m. P.M., and the ingress of its shadow at 11h. 31m. On the 6th a transit ingress of the first satellite at 8h. 59m., and ingress of the shadow of the satellite at 9h. 56m., the satellite itself passing off the planet's disc at 11h. 16m. On the 7th a reappearance from eclipse of the first satellite at 9h. 30m. 33s. On the 10th an occultation (disappearance) of the second satellite at 10h. 3m. On the 12th an egress of the shadow of the second satellite at 9h. 52m. On the 13th a transit ingress of the first satellite at 10h. 48m. On the 15th an

egress of the shadow of the first satellite at 8h. 37m., and a reappearance from eclipse of the third at 8h. 37m. 16s. On the evening of the 18th all four satellites will be seen in a line on the following side of the planet. On the 19th an ingress of the shadow of the second satellite at 9h. 46m., and a transit egress of the satellite itself at 10h. 10m. On the 21st at 9h. 57m. an occultation (disappearance) of the first satellite. On the 22nd a transit ingress of the shadow of the first satellite at 8h. 15m., an egress of the satellite itself at 9h. 22m., and an eclipse (disappearance) of the third satellite at 9h. 43m. 52s. On the 26th a transit ingress of the second satellite at 9h. 56m. On the 28th a reappearance from eclipse of the second satellite at 9h. 17m. 47s. On the 29th a disappearance by occultation of the third satellite at 8h. 46m., and a transit ingress of the first at 8h. 57m. On the 30th a reappearance from eclipse of the first satellite at 9h. 44m. 15s. Both Uranus and Neptune are practically invisible during August to the amateur observer. This month is one of the most favourable ones for observing shooting stars in. The most noted shower is that of the Perseids, with a radiant point at the maximum display on August 10 in 11h. 52m. +56°. Observations of this region of the heavens with an opera-glass will no doubt show stationary meteors, or meteors which shift their position very slowly. Their place and the direction of their shift should be noted for the purpose of determining whether the radiant is a geometrical point, or a circle, or an elliptic area, as suggested with regard to the November meteors.* The radiant point souths at 5h. 37m. A.M. The moon enters her first quarter at 1h. 27m. P.M. on the 4th, is full at 4h. 43m. A.M. on the 11th, enters her last quarter at 10h. 51m. A.M. on the 18th, and is new at 2 o'clock on the afternoon of the 26th. At 10h. 35m. P.M. on August 6 the $6\frac{1}{2}$ magnitude star B.A.C. 5758 will disappear at an angle of 103° from the lunar vertex, and reappear at 11h. 43m. P.M. at an angle of 297° from the vertex. On the 7th, Jupiter and three of his satellites will be occulted by the moon, the first satellite being behind the planet. The occultation of Jupiter takes place at 7h. 4m. P.M., at an angle of 25° from the vertex. The occultation of the planet itself will be preceded by that of the third satellite, and followed by that of the second, and after a little time by that of the fourth. This phenomenon will occur rather more than half an hour before sunset, and the altitude of the moon will be only 13°, so that probably at least four inches aperture will be required to see the satellites. The planet reappears at 8h. 1m., at an angle from the vertex of 290°. At 0h. 18m. A.M. the next morning the 6th magnitude star B.A.C. 6461 will be very near the north point of the lunar limb. On the 12th, at 4h. 7m. A.M., the 6th magnitude star 56 Aquarii will disappear at an angle of 107° from the vertex, and reappear at 4h. 57m., or a quarter of an hour after sunrise, at an angle of 5°. On the 13th, the 5th magnitude star 33 Piscium will disappear at 9h. 13m. P.M. at an angle of 118°, and reappear at 9h. 55m. at an angle of 212°. The 6th magnitude star B.A.C. 17 is occulted at 11h. 46m. P.M. on the 13th, at an angle of 107°, and reappears at 0h. 54m. A.M. the next morning, at an angle of 264°. On the 17th, at 4h. 35m. A.M., there is a near approach of B.A.C. 830, at an angle of 205°. At 1h. 37m. A.M. on the 20th, the $5\frac{1}{2}$ magnitude star B.A.C. 1563 disappears at an angle of 42°, and reappears at 2h. 35m. at an angle of 270°; and there is a near approach of h 106 Tauri at 3h. 33m. A.M. at an angle of 159°. At 2h. 59m. on the morning of the 24th, the 6th magnitude star η Cancri disappears at an angle of 107°, and reappears at an angle of 173° at 3h. 30m.

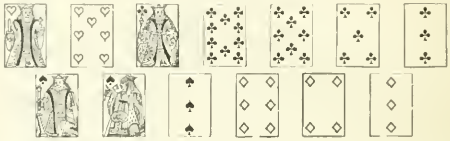
* "Monthly Notices" of the R.A.S., vol. xlvii. p. 69-73.

Whist Column.

By W. Montagu Gattie.

THE following hand, which is taken from "Whist Developments," by Cavendish, affords an interesting illustration of the principles of the American system of leads.

HAND No. 5.

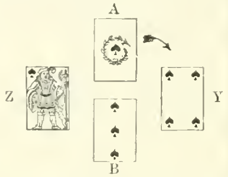


Score:—A B, 1; Y Z, 0.

Z turns up the 2 of hearts.

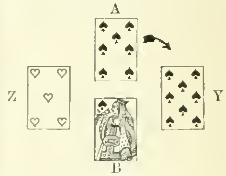
NOTE.—A and B are partners against Y and Z. A has the first lead; Z is the dealer. The card of the leader to each trick is indicated by an arrow.

Trick 1.



Tricks—A B, 1; Y Z, 0.

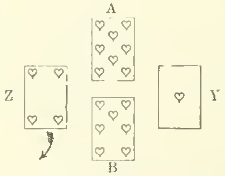
Trick 2.



Tricks—A B, 1; Y Z, 1.

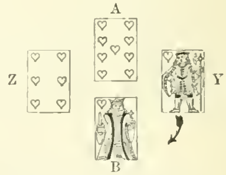
NOTE.—*Trick* 2.—A, on quitting the head of his suit, leads his original fourth-best (see KNOWLEDGE, p. 155). B infers that he has two better than the 7 (*i.e.*, 10 and 9), and the fall of the cards shows that he has all the others.

Trick 3.



Tricks—A B, 1; Y Z, 2.

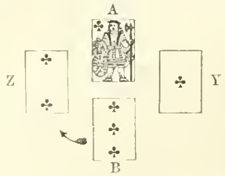
Trick 4.



Tricks—A B, 2; Y Z, 2.

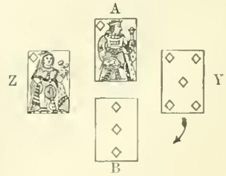
NOTES.—*Trick* 3.—Z has trumped with the 5, and now leads the 4, and he turned up the deuce. As will be seen when we come to discuss the management of trumps in connection with American leads, the rule is to trump with the fourth-best, and to lead the fourth-best of those remaining. Therefore Z has three trumps higher than the 5, and held at least six of them originally. *Trick* 4.—The 3 of hearts is marked in Y's hand; the remaining hearts are in Z's hand.

Trick 5.



Tricks—A B, 2; Y Z, 3.

Trick 6.

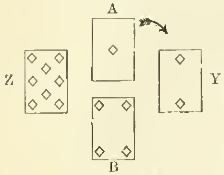


Tricks—A B, 3; Y Z, 3.

NOTE.—*Trick* 5.—B does not lead the king of spades, because he knows one adversary will trump and the other will discard (see notes to Tricks 2 and 4). His object is to secure the required four tricks in clubs and diamonds (see score), and to prevent the adverse trumps from making separately. Nothing is to be gained by leading the

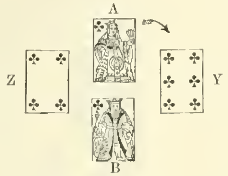
fourth-best club, and exposing the hand with all the trumps against, and B therefore leads the smallest.

Trick 7.



Tricks—A B, 4; Y Z, 3.

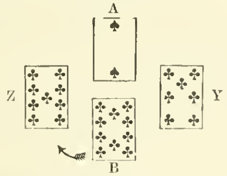
Trick 8.



Tricks—A B, 5; Y Z, 3.

Note.—B wins A's queen of clubs, the only chance being that Y and Z may each hold another club. If A remains with the lead, he must continue with a spade; Y of course trumps, and Z discards his losing club, and wins all the remaining tricks.

Trick 9.



Tricks—A B, 6; Y Z, 3.

YZ win the remaining tricks, and score the odd trick and two by honours, and

AB save the Game.

A's Hand.	B's Hand.	Y's Hand.	Z's Hand.
H.—9, 8.	H.—Kg, 7.	H.—Ace, Kn, 3.	H.—Qn, 10, 6, 5, 4, 2.
S.—Ace, 10, 9, 7, 6, 5, 2.	S.—Kg, Q, 3.	S.—8, 4.	S.—Kn.
D.—Ace, Kg.	D.—6, 4, 3.	D.—Kn, 9, 7, 5, 2.	D.—Qn, 10, 8.
C.—Qn, Kn.	C.—Kg, 10, 8, 5, 3.	C.—Ace, 7, 6.	C.—9, 4, 2.

Remarks.—At Trick 7 A leads the ace of diamonds, as, if he keeps a card with which he can get the lead when he has only spades left, he must lose the game.

If, at Trick 2, A leads the deuce of spades, as was the practice before the introduction of American leads, AB lose the game, for the reason that B cannot place the spade suit. In that case, at Trick 5, B will lead the king of spades to force the strong trump hand. In this he will succeed; but he will also enable Y to discard a club. Z, following this indication of Y's suit, will lead the queen of diamonds; A winning with the king of diamonds will continue with the queen of clubs, to which Y will play the ace; and whether Y leads diamonds or clubs, A B will not be able to make more than five tricks, and will therefore lose the game.

On the other hand, it may be pointed out that Z affords B valuable information as to the position of the trumps by his play at Tricks 2, 3, and 4. It so often happens that such information is useful in playing a defensive game that some good players are opposed on this account to the extension of the American code to the trump suit.

Elementary Explanation of the Play.

Trick 1.—A opens his longest suit and leads the ace, which is the correct play when holding four or more others. Y, B, and Z play their smallest spades.

Trick 2.—A rightly continues his suit so as to clear it if possible. He is not deterred by the fall of the knave, for Z may have both king and queen, and in any case A is too weak to lead trumps. As things turn out, he forces a trump from the strong trump hand, although Z is so rich in them that it makes no difference to him. Note that the king of spades after this trick is marked in B's hand.

Trick 3.—Having still five trumps to the queen left, Z leads a small one; excepting the queen of diamonds he has no plain cards of his own to protect, but he plays to save any good cards his partner may hold from falling to a hostile "ruff." Y of course plays the ace, so as to ensure a second round.

Trick 4.—Y follows the almost invariable rule to return a partner's trump lead at the first opportunity, and, as he has only two of the suit remaining, he rightly leads the higher of them. With knave and two others left, he would return the lowest. Z plays the 6 to show that he has it, for his partner knows that he has the deuce as it was the turn-up card.

Trick 5.—B having reason to think that by continuing his partner's suit he will enable one adversary to trump and the other to discard, determines to open his own long suit. A, as third player, having two cards in sequence, plays the lower one; B now knows that the queen is with A or Z, since Y has to win knave with ace; but if A had played the queen, there would have been no evidence at all as to the whereabouts of the knave.

Trick 6.—Y opens his longest suit.

Trick 7.—Ordinarily A should retain as long as possible the command of his adversary's suit; but, as has already been explained, there is a special reason for his disposing of any card that would put the lead into his hand later on. Therefore he leads out his ace of diamonds.

Trick 8.—The queen and knave of clubs being played, the king and 10 are of equal value. B knows that his partner has no more clubs (for he has all the remaining spades), and he wins the queen, as the only chance of making another trick in the suit, and so saving the game.

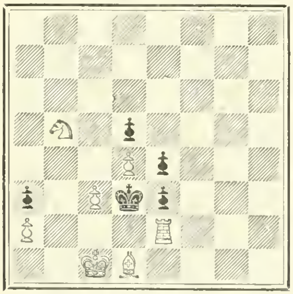
Chess Column.

By I. Gunsberg (Mephisto).

[Contributions of general interest to chess players are invited. Mr. Gunsberg will be pleased to give his opinion on any matter submitted for his decision.]

PROBLEM BY HERR EICHSTADT.

Black.



White.

White to play and mate in three moves.
White, seven pieces; Black, five pieces.

Game played May 2, in the New York Tournament.

Irregular Opening.

White. J. M. Hanham.	Black. I. Gunsberg.	White. J. M. Hanham.	Black. I. Gunsberg.
1. P to Q4	P to Q4	24. B to Kt4	B to Q2
2. P to KB4 (*a*)	P to KKt3 (*b*)	25. B to R4	Kt to B4 (*n*)
3. P to K3	B to Kt2	26. B to B2	P to KR4 (*o*)
4. B to Q3	P to Kt3	27. B to K2	Kt to Q3 (*p*)
5. P to B3 (*c*)	B to Kt2	28. BP × P	P × P
6. Kt to B3	Kt to Q2 (*d*)	29. P × P	B × P
7. QKt to Q2	KKt to B3	30. Kt to B4	Q to B2 (*q*)
8. Castles	Castles (*e*)	31. B to B3	B to K3
9. Kt to Kt5	P to K3	32. Kt × B	Q × Kt
10. R to B2	Kt to Ksq	33. Q to Q3	K to Kt2
11. Kt to Bsq	Kt to Q3 (*f*)	34. Kt to Q2	Kt(Q3) to B5 (*r*)
12. Kt to Kt3	P to QB4 !	35. Kt to Ktsq (*s*)	B to B3
13. B to Q2 (*g*)	Q to K2 (*h*)	36. P to Kt4	P × P
14. B to Ksq	QR to Bsq	37. B × P	R to Q2
15. R to QBsq	R to B2	38. Q to B3	Kt to K4
16. KR to B2	KR to Bsq	39. Q to K2	Kt to Kt5
17. Kt to Bsq (*i*)	P to B3	40. B to B5	Kt to R5 (*t*)
18. Kt to R3	P to K4 (*j*)	41. Q × P	Kt × B
19. B to B2	P to B5 (*k*)	42. P × Kt	R(Bsq) to Qsq (*u*)
20. B to K2	B to B3 (*l*)	43. B to B3 (*v*)	Q to K6 (ch) (*w*)
21. P to QKt3	P × P	44. K to Rsq	R to Q8 (ch)
22. P × P	P to QKt4 (*m*)	45. Q to Bsq	Q to B5
23. P to QKt4	Kt to Kt3	Resigns	

NOTES.

(*a*) This move constitutes the Stone-wall Opening. As its name implies, the object is to erect a strong barrier against Black's advance, and to secure a draw thereby.

(*b*) I find that the cross-action of the two Bishops posted on KKt2 and QKt2 may be utilised with great effect in close games. Black must, however, always be alive to the danger of a possible advance by White on the King's or Queen's Bishops' files; he must also keep his Pawns well in hand until the proper moment arrives for an advance on the flank of the lines commanded by the Bishops.

(*c*) It is an advantage for Black that White is induced to make such an inactive move, blocking one square of the QKt, and forego any intention of an immediate advance on the Queen's side.

(*d*) White having rendered his Queen's side inactive, it is Black's intention (after having provided for his own safety) to advance, *via* P to QB4, with the hope of placing a Pawn on B5, or, otherwise, weakening the White Queen's side. This is the plan of battle on which the whole game is decided, as will be seen.

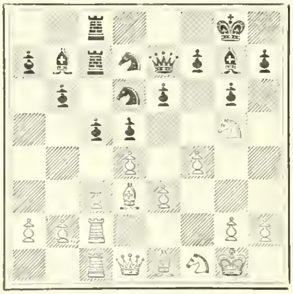
(*e*) Black now has less to fear from an advance on the King's side; still he should have played P to K3 earlier.

(*f*) This Knight is very well posted both for attack or defence, and the QKt is made available to play to B3 if necessary; a break-up of the position by means of P to K4 by White is also prevented, and Black has greater freedom of action.

(*g*) To take the Pawn would not be good as Black would obtain the open Kt's file, and the possibility of attack by Q to Kt3 in conjunction with the position of the KB on Kt2 would constitute a weakness in White's game. White's intention seems to be to post his QB on KB2 in defence of his Pawn.

(*h*) Makes the KR available for the advance on the Queen's side for which Black is steadily working, and it also liberates the KBP for an advance if necessary.

I. GUNSBERG.
BLACK.



WHITE.
J. M. HANHAM.
Position after White's seventeenth move.

(*i*) It is not quite clear why he retired the Kt; perhaps he had some intention of advancing on the King's side, but found that it was rather *too late*.

(*j*) Every piece of Black supports the advance, and whichever way White takes, Black obtains a strong centre; whereas the White King's Pawn will remain very weak.

(*k*) Black has waited until the position is ripe for this advance. It is difficult to decide whether P to K5 would not have blocked the game too much. Now, although P to B5 also seems to block the game, yet a player is never at a loss to continue the pressure in a similar position, against the Queen's side.

(*l*) A very effective demonstration, which compels White himself to open up the Queen's side. Black threatens B to R5. Against this R to Q2 is no good on account of Kt to K5, he has therefore nothing left, but to move his QKtP which opens up the file for the two Rooks, as if they had been played there for the purpose, by pre-arrangement.

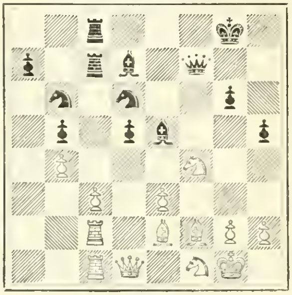
(*m*) To prevent White getting rid of his weakness by playing P to B4.

(*n*) Gaining time as White cannot take the Kt without losing the QBP.

(*o*) Compelling the other B to retire for the same reason.

(*p*) P to K5 would have made the game much harder, but Black's advantage on the Queen's side ought to have told in his favour. White now seizes a favourable opportunity to relieve the pressure and simplify matters by exchanging.

I. GUNSBERG.
BLACK.



WHITE.
J. M. HANHAM.
Position after Black's thirtieth move.

(*q*) White has succeeded in obtaining a counter attack. If Black plays B × Kt the White B finds a strong square on Q5.

(*r*) Black was bound to prevent the Kt playing to Q4 *via* Kt 3. If now Kt to Kt3 Black plays Kt to R6.

(*s*) This gives Black very valuable time.

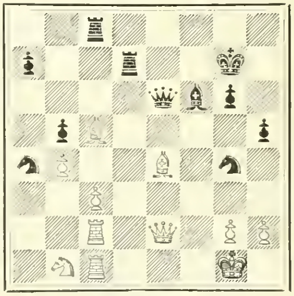
(*t*) The game was adjourned in this very interesting position. It does not seem that White has any good square to play his Bishop on, and the move that follows is the natural outcome of the position.

(*u*) White did not foresee this move when capturing the Pawn.

(*v*) This is fatal at once, but his game was bad anyway, for if, instead of this, 43. Q to K2, Q to K4. 44. P to Kt3, B to Kt4, threatening if R moves B to K6(ch) winning.

(*w*) Black now forces the mate in a few moves.

I. GUNSBERG.
BLACK.



WHITE.
J. M. HANHAM.
Position after Black's fortieth move.

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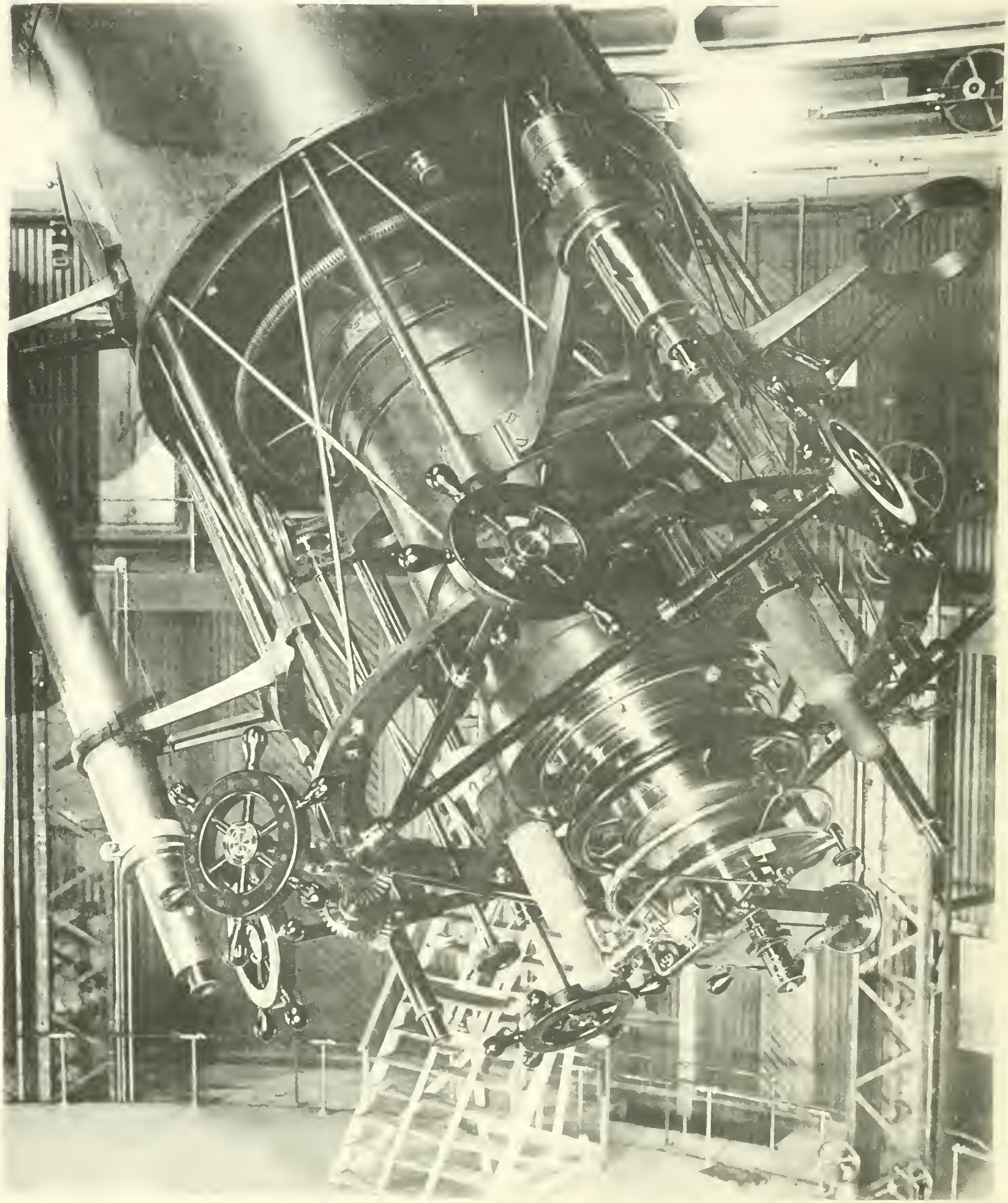

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SIMPLY WORDED—EXACTLY DESCRIBED

LONDON: NOVEMBER 1, 1889.

CONTENTS.

THE COMMON COCKROACH.—IV.

By E. A. BUTLER.

IN order to complete the sketch already given of the digestive system, we have yet to notice some important accessory organs, the salivary glands, which in the cockroach are enormously developed. On opening the body, they may be seen lying along just outside the walls of the crop in its anterior part. Each consists of a pair of white glands (Fig. 9) and a very thin-walled, elongated bag or receptacle, quite distinct from these; each gland, though apparently compact, really consists of a flattened tree-like structure, the foliage portions of which contain the cells which secrete the saliva, while the branches are minute tubes which convey it, when secreted, from the gland. A narrow tube, or "duct," formed by the union of the above branches, receives the salivary fluid from each gland, but the two ducts of each side soon unite into a single one, and the two thus formed again coalesce and form one main central tube lying under the œsophagus. Similarly the ducts of the receptacles unite in a single central canal, which receives, a little beyond this junction, the common duct of the glands, and so finally only one tube remains as the representative of the original six, and this opens into the mouth behind the tongue.

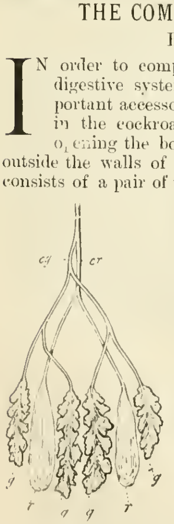


FIG. 9.—SALIVARY GLANDS OF COCKROACH. *g*, glands; *r*, receptacles; *cg*, common duct of glands; *cr*, common duct of receptacles.

Like other terrestrial insects, a cockroach breathes by taking in air, not through its mouth, but at certain openings in the sides, called spiracles, or *stigmata*. There are ten of these on each side, eight pairs being situated in the abdomen and the other two in the thorax. Those belonging to the abdomen are not very easy to detect, as they are small and all but one pair obscurely situated. The chitinous integument which bounds and determines the form of each segment of the abdomen is not a complete ring round the body, but consists of two distinct parts, a band across the back, called the *tergum*, and another underneath, the *sternum*; these are united towards their edges by a membranous junction, and it is in this at the junction of the segments that the stigmata lie, concealed by the overlapping edges of the terga and sterna. Each is an oval aperture situated on the summit of a small conical eminence (Fig. 10), and capable of being closed by an internal valve, whereby dust and other foreign matters are excluded. A large tracheal tube proceeds from each, and very soon begins to subdivide into smaller ones, the ultimate ramifications of which pass to the remotest parts of the body, and even into the jaws, wings, legs, and antennæ. By means of this system of tubes air is conveyed to all parts of the organism, so that the blood is aërated, not, as in most kinds of animals, by being brought from the body at large and collected in some special organ, such as a lung or a gill, there to come into contact with the air, but by having the air conveyed to it in all parts of the body at once.

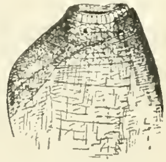


FIG. 10.—ABDOMINAL SPIRACLE OF COCKROACH.

The introduction and expulsion of air is, of course, accompanied by movements of the body walls, but these are not very easy to see as they are but slight in amount. Plateau succeeded in demonstrating their character and extent by the ingenious method of projecting the form of the body of the living insect on a screen by means of the lantern, and then tracing its outline during inspiration and expiration respectively. In general, an insect at rest performs its respiratory movements with the hinder part of its body, in other words, it pants with its *abdomen*, the movements consisting of an alternate contraction and recovery of shape of that region. Amongst British insects there is perhaps no species in which it is easier to watch these movements than the great green grasshopper, a large locust-like insect found not unfrequently in some parts of the country. By the contraction of certain abdominal muscles, the upper and lower walls of the abdomen are drawn together to the extent, in the cockroach, of one-eighth of the entire depth of the body, and a compression from side to side takes place at the same time; the tracheal tubes are thus compressed, and air is forced out at the stigmata; on the relaxation of the muscles, the elasticity of the tracheal tubes themselves, resulting from the coiled spiral thread in their interior, then restores the body to its normal form, while air in consequence enters at the stigmata. In the cockroach, the thoracic segments have sufficient mobility to permit of their taking some part in the movements of respiration, even when the insect is at rest, in which respect it differs from most other insects. In order, therefore, clearly to realise how a cockroach breathes, we have to bear in mind that, concurrently with the rise and fall of the body walls, ten little jets of air alternately enter at and issue from as many openings in the insect's sides, the outward-tending jets of course carrying with them the carbonic acid and water vapour produced as the insect discharges its vital functions.

But the respiratory movements above described can scarcely be regarded as providing a complete explanation

of the mechanism of breathing. For they would simply have the effect of renewing that portion of the contents of the tracheal tubes which is in the parts nearest the spiracles, and the air in the minute and remote subdivisions of the tracheæ would have no chance of being expelled, and would simply oscillate up and down the tubes and never reach the outer air at all. How this difficulty is met is not at present altogether clear, but it seems certain that we must look to the principle of gaseous diffusion as at any rate aiding in producing the required result of the penetration of oxygen to the remotest parts of the system, and the corresponding outward passage of the carbonic acid formed. The rate of breathing depends upon a variety of circumstances. It is quickened by whatever increases the general activities of the insect; thus, a swiftly running cockroach breathes more quickly than one at rest, and, again, a well-fed individual is naturally more vigorous and inclined for exertion than a lean and emaciated one, and its respiration becomes in consequence more rapid. Cold, on the other hand, has a benumbing effect, and the rate of breathing therefore falls with the temperature.

The extreme perfection of the respiratory system is closely connected with and correlated to a very rudimentary condition in the circulatory apparatus. As the air is conveyed to every part of the body, and oxygenation can take place anywhere, there would clearly be no object in having any special apparatus for the collection and guidance of the blood. A cockroach has indeed, as already mentioned, a heart, but beyond this it can scarcely be said to possess any circulatory system. Anyone who brings to the examination of a creature such as this the popular conception of what a heart is like, will certainly fail to find anything which bears the remotest resemblance to such conception. There is, in fact, no compact, chambered, fleshy, conical body such as we are familiar with in vertebrate anatomy; the "heart," so called from its function, not its form, is merely an inconspicuous, elongated soft tube, with sundry openings in its sides through which blood enters it from the body at large. Nor is its position such as might have been anticipated; we must look for it, not towards that side of the body which faces the ground, but on that which is uppermost, for it lies along the whole length of the back, just beneath the skin, in the middle line. Nor, again, does this rudimentary heart communicate with any system of blood-vessels for conducting the blood on its tour round the body; for the blood, on being expelled from the orifice at the extremity of the tube, is simply passed on through the various interstices between the different viscera, until it ultimately finds itself back again at the place it started from. Hence it is manifest that every movement of the body which in any way disturbs the relative position of the internal organs will assist, to some extent, in urging the blood along its course. Nor, finally, is the blood itself exactly what its name might suggest; if a cockroach is wounded, blood will, of course, issue from the wound, but as it is only a colourless liquid, a little stretch of the imagination is required to realise that it is the true nutrient fluid of the body.

By the dissection which removes the digestive tract, the main part of the nervous system is laid bare. It is constructed similarly to that of the earthworm, and consists of a chain of nervous centres or ganglia, in pairs, connected with one another by nervous threads (Fig. 11), and extending from one end of the body to the other. The greater part of it lies between the digestive tract and the under surface of the body, and is therefore nearest the ground when the animal walks. Here again, therefore, all preconceived notions gathered from the familiar vertebrates are upset, as we trace the great nerve-centres, not down the back, but in exactly the reverse position. The foremost pair of ganglia, however, which are situated in the head and have been dignified with the name of "brain," as they send nerves to the sense organs, viz. the eyes and antennæ, lie above the œsophagus, being connected by two thick bands of nervous tissue with the first pair that underlie it, so enclosing that portion of the digestive tract as in a collar. While examining the distended crop as it lies in its natural position, a small nervous ganglion may be observed as a little triangular whitish spot on its upper surface about half-way down its length; from this two nerves pass obliquely backwards towards the hinder part of the crop, while a single one running forward along the middle line connects this centre with some small ganglia in the neighbourhood of the brain. This small collection of nerves and ganglia is called the visceral nervous system.

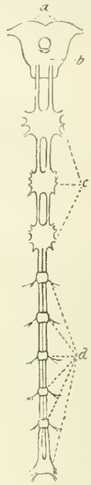


Fig. 11. — Nervous Chain of Cockroach. *a*, supra-œsophageal ganglia; *b*, sub-œsophageal do.; *c*, thoracic do.; *d*, abdominal do.

Such is the insect which foreign commerce has introduced to our island, and which, by reason of the persistence with which it clings to the fortunes of the human race, has become truly cosmopolitan, and seems to be almost a necessary adjunct of modern civilisation. Nowhere a welcome guest, it yet quietly pushes on its conquests, and even the determined hostility of the tidy housewife does not avail to check its progress. Its nocturnal habits and love of concealment make it a very difficult insect to eradicate when once it has established itself in a house, and it is to be feared that no certain remedy for this nuisance has yet been discovered. Spite of "beetle-traps" and "vermin-powders," it maintains its ground; neither rats, cats, nor hedgehogs (all numbered amongst its foes, and the last especially a greedy devourer of it), are able materially to lessen its numbers; by reason of some subtle superiority, perhaps impossible for our gross senses to perceive, it continues to be victorious over all its enemies, and in the face of all opposition and efforts to exterminate it, still flourishes and continually spreads. It is, indeed, gradually dislodging an old and familiar inhabitant of kitchens, the house-cricket, an insect of very similar habits to itself, and no very distant relation of its own.

P. orientalis is not the only species of cockroach which attaches itself to man. A considerably larger species, *P. Americana*, which is winged in both sexes, has spread a good deal from its native haunts in Tropical America, and has effected a lodgment in some places in this country. But for some reason or other, it does not seem likely to displace *orientalis*, a curious fact, inasmuch as it is a stronger insect, and, being gifted with wings in both sexes, might be supposed to have had better opportunities of establishing itself. It is a common species on board ships. An Australian species also appears to be beginning to spread. Again, *Blatta germanica*, a closely allied form called in America the "Croton Bug," is known all over the United States, and sometimes gets a footing in Britain. In a baker's shop at Leeds it established itself, and is said to have been introduced by soldiers after the Crimean War, coming with them to the barracks, and being thence conveyed to the bakery in bread baskets. According to

Hummel, this species assists its young to escape from the egg case; he introduced a female into a bottle containing one of the cases; she immediately seized it, and slit it open with her jaws, and tore off the enveloping membranes of the contained young.

Besides house-cockroaches, we have in this country field-cockroaches, *i.e.* indigenous species that habitually live out in the open and do not attach themselves to mankind. They are smaller than *P. orientalis*, and may be found in sandy places and amongst dead leaves and other vegetable rubbish. They have sufficient superficial resemblance to *P. orientalis* to be recognisable as coming into the same category, although their colour is generally much paler. In addition to these, large numbers of species occur wild in other countries; but why just those particular species mentioned above, and especially *P. orientalis* itself, should have become dependent upon the human race, while so many others have either not attempted to do so, or have not succeeded if they have attempted, is still shrouded in mystery. The chief peculiarity by which *orientalis* is distinguished from its fellows, viz. the apterous condition of the female, seems rather as though it might militate against its chances than favour them.

THE FISH-LIZARDS OF THE SECONDARY ROCKS.

By R. Lydekker, B.A., Cantab.

So long ago as the year 1814, when a fine example of a large skull (now in the British Museum) was figured by Sir Everard Home in the "Philosophical Transactions" of the Royal Society, the occurrence in the so-called Lias of the Dorsetshire coast of skeletons of huge and uncouth reptiles, strangely unlike any of their modern cousins, was well known. Five years later the same writer described other specimens, and proposed that these extinct Saurians should be known as the *Proteosaurus*, or Primeval Lizard. Now, strictly speaking, this name, as the earliest, ought to have been adopted for all time, but, unfortunately, the late Mr. König, some time keeper of the Geological Department of the British Museum, affixed to the specimens of these Saurians under his charge the name of *Ichthyosaurus*, or Fish-Lizard; and this name was adopted in the year 1821 by the late Rev. Mr. Conybeare, who, in conjunction with the late Dean Buckland, of Oxford, did so much towards our knowledge of the structure of these and other fossil Saurians. This name has now become so thoroughly established—being, in fact, almost an English word—that, in spite of the injustice to Sir Everard Home, it seems too late to attempt its suppression.

We have said that the Fish-Lizards have left their remains in those beds of rock which are called by the quarrymen Lias, or Layers (the name being derived from their banded and ribbon-like appearance); and before proceeding to discuss the structure of these creatures, a word or two is advisable as to the geological position of the formation. The Lias comprises a thick series of beds, usually of a bluish colour, lying very low down in that enormous series of rocks known as the Secondary system, of which the Chalk is the topmost member, while the middle part of the system is formed by the great series of Oolites and their accompanying clays. The Secondary system itself, it need hardly be said, lies upon the upper part of the Primary system, as represented by the Coal Measures; while it is succeeded by the overlying deposits of the Tertiary system. In regard to the upper parts of the latter system, it is possible to make some more or less vague approximation in terms of thousands of years as to their real age, but in the Secondary period any such approximation is totally impossible, and we can only reckon the age of the various beds by geological periods, as represented by the vertical thickness of overlying rock. Now, since the Chalk may exceed 1,000 feet in thickness, and there are several deposits of equal bulk between this and the Lias, some faint idea may be thereby conveyed of the vast lapse of time by which we are separated from that period when the mud of the Lias was deposited in the shallow seas of what is now England. The Fish-Lizards were, however, by no means confined to this remote Liassic period, since they also occur not only in the underlying New Red Sandstone, or Triassic series, which forms the very base of the Secondary system, but likewise lived on through the period of the Oolites and Chalk, till they finally died out, so far as we are aware, with the close of the Chalk period. The Fish-Lizards are, therefore, characteristic of the Secondary period, so that when we pick up one of the joints of their backbones (of which more anon) we know that it must have come from some part of that great system, even though we find it embedded in the gravels lying above the Tertiary system. One more important point remains to be mentioned in connection with the beds in which the remains of these Fish-Lizards occur; and this is, that they are all deposits formed by the sea, by which we are led to conclude that these saurians were of marine habits. Again, it may be observed that whereas in the Lias the remains of the Fish-Lizards are usually found in the condition of more or less nearly complete skeletons, with every bone but little shifted from its natural position; in the overlying rocks the skeletons are generally more or less dislocated and imperfect. Although the latter condition renders us unable to restore the complete skeleton of these latter forms, yet it has had the compensating advantage that we are able to handle and examine the individual bones in a manner which is generally quite impossible with the skeletons from the Lias, where the bones are often distorted and flattened by pressure.

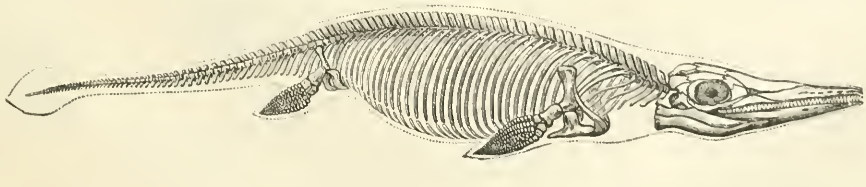


Fig. 1.—Greatly Reduced Restoration of the Skeleton of the Common Fish-Lizard of the Dorsetshire Lias.

We are now in a position to consider a few of the more prominent features in the structure of these primeval

saurians; of which the whole organisation is better known than that of most of the other reptiles of the same epochs. In the woodcut (Fig. 1) we give a copy of Sir Richard Owen's restoration of the entire skeleton, together with a conjectural outline of the contour of the body when clothed with flesh and skin. It will be seen from this that the contour of the entire animal was of a whale-like type; there being no distinct neck, the body gradually passing into the tail, and the two pairs of limbs forming paddles or flippers, adapted, like those of a turtle, for propelling the body through the water, and perhaps also permitting their owner to crawl awkwardly on the sea-shore in the same manner as the turtle does. From the circumstance that in the skeletons from the Lias the tail is nearly always broken at some distance from its extremity, it has been suggested that the tail was furnished with a terminal fin, after the fashion of the "flukes" of the Whales. In some instances the fine-grained Lias mud has preserved traces of the outer surface of the skin of the Fish-Lizards, and we learn from this, and also from the absence of any traces of bony plates like those found in the skin of crocodiles, that the skin of these saurians was quite naked; and we are thus shown another feature in which they resemble whales. Moreover, in certain very rare instances, as is shown in the beautiful example represented in Fig. 2, which has been

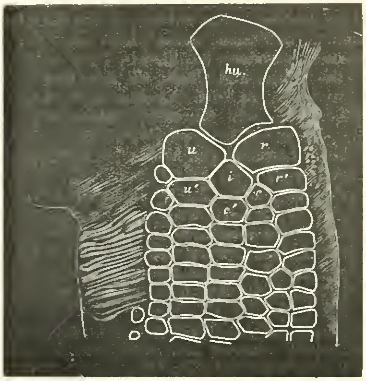


Fig. 2.—Part of one of the Fore Paddles of a Small Fish-Lizard from the Lias of Barrow-on-Soar. *hu*, bone of upper arm; *r*, *u*, bones of fore-arm; the other letters indicate the bones of the wrist, below which are the bones of the fingers.

recently presented by Mr. M. Browne, of the Leicester Museum, to the National Collection, the contour of the soft parts of the paddles is accurately delineated in the stony matrix. We thus see that the fleshy part of the paddle formed but a comparatively narrow band in advance of the bony framework on the front border of the fin (right side of Figure); but on the opposite or hinder border (left side of Figure) we find the soft parts forming a broad fin-like expansion admirably adapted to obtain the full advantage of the stroke of the limb in swimming.

As we are on the subject of the paddles, we may take the opportunity of noticing the very remarkable structure of their bony framework, which is quite unlike that found in any other animal, although evidently only a modification of the same ground-plan. In most vertebrate animals, as in man, the skeleton of the arm, or fore limb, presents the following features:—The upper-arm has one long single bone; in the fore-arm there are two slender bones lying side by side and separated by an interval; the wrist has two rows of small cuboidal bones; while the limb terminates in five fingers, of which, with the exception of the thumb, each has three long bones, which are respectively separated from the wrist by a similar but somewhat longer bone. Turning to the fore paddle of the Fish-Lizard (Fig. 2), we easily recognize in the topmost bone the single bone of the upper arm, although this has become much shorter and thicker than is usually the case. In the two short and angulated bones, marked *r* and *u*, it is more difficult to recognize the representatives of the long bones of the fore-arm; but that they really are such representatives is at once shown by their position. Passing over the bones of the wrist, we find that the bones corresponding to those of the fingers, instead of being elongated and limited to three in each of the five fingers, are polygonal in contour, and arranged in as many as seven or eight longitudinal rows, while those of each finger (as shown in Fig. 1) are exceedingly numerous. The whole structure forms, in fact, a complete bony pavement, which in the living animal must have been perfectly supple, and thus have formed one of the most efficient and powerful swimming organs known in the whole animal kingdom. The paddles of the whales resemble those of the Fish-Lizard in the great number of bones in each finger, but they differ in that the number of the fingers themselves does not exceed the universal five.

In the few words that we can devote to the skull of the Fish-Lizard, we may observe that the muzzle was produced into a more or less elongated beak (Fig. 1), while the nostrils were placed close to the eye, and the soft parts of the latter were strengthened with a ring of bony plates surrounding the iris and pupil, as is the case in birds. The teeth were large and pointed, and implanted in a deep groove in the jaws. Their pointed crowns at once tell us that the Fish-Lizards were creatures of carnivorous habits, which preyed on other inhabitants of the Secondary seas. Curiously enough in the approximation of the nostrils to the eyes, and also in their sharply-pointed teeth, the Fish-Lizards present further resemblances to the Whales, resemblances which we may probably explain by the similar conditions of life of these two widely different groups.

Before leaving this brief notice of the anatomy of these saurians, a few words must be said as to the structure of the back-bone or vertebral column. It will be seen from Fig. 1 that the whole of this column forms a continuous

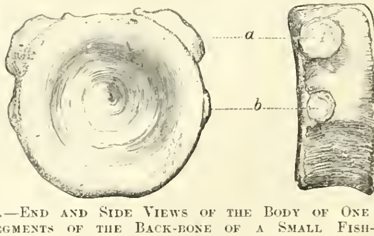


Fig. 3.—End and Side Views of the Body of One of the Segments of the Back-bone of a Small Fish-Lizard. *a*, *b*, Surfaces for the attachment of the rib.

series, tapering at the two extremities; and the various segments, or vertebræ, of the different regions of this column are so alike that it requires some practice to distinguish them. As is well known, each vertebral segment in all the vertebrate animals consists of an arch enclosing the spinal marrow, and of a sub-cylindrical body supporting the arch and underlying the marrow. As a rule, the body and the arch are more or less firmly united together, but

in the Fish-Lizards they remain quite separate throughout life. Further, the body of each vertebra (Fig. 3) forms a disk, which is deeply concave at the two extremities, like the vertebræ of a fish, and quite different from those of most living reptiles, in which the bodies of the vertebræ articulate with one another by a ball-and-socket joint. Another peculiarity of the back-bone of the Fish-Lizards is in the mode of attachment of the ribs. Thus each rib terminates in a fork, of which the two prongs articulate with the two knob-like surfaces on the side of the body of each vertebræ, as shown in Fig. 3.

Some of the species of Fish-Lizards attained a length of from thirty to forty feet, and were thus truly Leviathans of the deep.

The result, then, of our brief survey of the chief structural peculiarities of these extinct saurians is to show that they were Whale-like marine reptiles of carnivorous habits, with a naked body, provided with four paddles, and probably with a tail fin, and that they had fish-like vertebræ, and a long-toothed beak to the skull. In certain American representatives of the group the jaws were, however, totally unprovided with teeth; and in these and allied types from the Oolites of England a third bone articulated with the bone of the upper arm (*hu* of Fig. 2), thus making the structure of the paddle still more peculiar. How these toothless Fish-Lizards captured and held their prey is not very easy to understand; but it is possible that instead of living on hard mail-clad fishes like their toothed cousins of the Lias, their food may have been of a softer nature, such as cuttle-fishes.

In stating that the Fish-Lizards of the Lias subsisted largely on the mail-clad "Ganoid" fishes of the same epoch, we may perhaps be thought to be drawing upon our imagination. This, however, is not the case, since we frequently find the whole contents of the stomach of these reptiles preserved within the cavity of their ribs, which shows us that their food was composed not only of these fishes, but also of young individuals of their own genus. In very rare cases, moreover, there are found within the body-cavity of large individuals very small skeletons of other Fish-Lizards; and since these young skeletons are always entire and belong to the same species as the one within whose body they are enclosed, it has been concluded that some Fish-Lizards brought forth their young in a living condition. This conclusion being certainly one of the most startling and unexpected results which has rewarded the students of this branch of palæontology.

Whether, when the name of Fish-Lizards was first given to these saurians, it was in the mind of its author that they were really related to fishes, cannot now be certainly known. It has, however, been subsequently suggested that these reptiles are the direct descendants of fishes; but since, like Whales, they breathed air by means of lungs, a recent writer has pointed out that if such descent were really the case it is almost certain that the Fish-Lizards would have continued to breathe air by means of gills, after the manner of fishes. And it is, therefore, considered probable that these saurians are the descendants of still earlier land reptiles; in which respect they again present another resemblance to Whales, which, as Professor Flower has shown, appear to have been derived from land animals more or less nearly allied to the hoofed quadrupeds or mammals. If, now, we look back and endeavour to fix upon the ancestral type of reptiles from which the Fish-Lizards have probably been derived, we find that in the period of the Coal and the succeeding first stages of the Secondary epoch there existed a remarkable group of reptiles, which, in the adult stage, were inhabitants of the land and breathed by means of lungs. From the very peculiar labyrinth-like internal structure of the teeth of these early reptiles the group is collectively known as the Labyrinthodonts. Now it is very suggestive that the teeth of most species of Fish-Lizard retain traces of this very remarkable labyrinthic structure; and since, moreover, the skull of these saurians has certain peculiar features also found in that of the Labyrinthodonts, while the structure of the backbone is very similar in the two groups, it seems highly probable that the Fish-Lizards have been directly derived from ancient reptiles more or less closely allied to the Labyrinthodonts, if not from that group itself; and that as they gradually became more completely aquatic their limbs were developed into the very complex paddles of the typical forms.

In conclusion, we have already pointed out several remarkable resemblances between the ancient Fish-Lizards and the modern Whales, and we have regarded such resemblances as due to their similar mode of life. The Fish-Lizards may, indeed, be considered to have occupied that place in the Secondary period which is now held by the Whales; and it becomes curious to reflect why these saurian devastators of the deep should have died at the close of the Secondary period, to be succeeded during the Tertiary by the mammalian Whales. This, however, is unfortunately just one of those deeply interesting problems to which science gives us no answer.

THE ETHNOLOGICAL SIGNIFICANCE OF THE BEECH.

By Canon Isaac Taylor, Litt.D., LL.D.

THE new science of linguistic palæontology has thrown a flood of light on several obscure problems of ethnology. It has, for instance, been proved that the names of the ass and the camel in Aryan languages are not primitive, but merely loan words from the Semitic. This fact, by itself, goes far to disprove the hypothesis which placed the cradle of the Aryans in Central Asia, a region of which these animals are natives.

Perhaps in no case have more valuable results been obtained than in the case of the beech. This tree, which flourishes only in temperate climates, and is a lover of chalk sub-soils, is confined to a definite and restricted area. It grows in the extreme south of Norway and Sweden, but is not found east of a line which strikes across Europe from the Frische Haff on the Baltic coast near Königsberg, through Poland to the Crimea, ending finally in the Caucasus.

In former times the limit was more narrowly restricted. In Cæsar's time the beech had not reached Britain or Holland, while at the close of the bronze age, or the beginning of the iron age, it was only just beginning to replace the oak in Denmark. Early in the neolithic age its range was probably confined to France, Northern Italy, and Northern Greece, while in Germany, as Dr. Schrader believes, it did not extend north of the Thuringian forest. It flourishes in Macedonia, and clothes the north-eastern slopes of the Thessalian coast chain, while in the south of Epirus the ilex or evergreen oak replaces it as the characteristic forest tree.

Within these ancient limits of the beech we must place the cradle of four Aryan languages—German, Latin, Celtic, and Greek. We draw this conclusion from the following philological facts:—The word for beech is, in Gothic, *bôka*; in Latin, *fagus*; in Celtic, *faidhbhil*; while the corresponding word, φηγός, denotes the oak in Greek.

With regard to other members of the Aryan family, the names for the beech, *buky* in old Slavonic, *bukas* in Lithuanian, and *buk* in Russian, are manifestly loan words from the German. This would go to prove that the Slaves, in the prehistoric period, must have dwelt east of the beech line, though they have since advanced within it. Johannes Schmidt has shown reason for believing in the unbroken geographical continuity of the European Aryans, previous to the linguistic separation. Hence they must be placed astride, so to speak, of the beech line—the Slaves and Lithuanians in European Russia, and the Celts, Latins, Hellenes and Teutons farther to the west.

We have now to account for the fact that the word denoting the beech in Latin, German, and Celtic, has come in Greek to denote not the beech but the oak. A well-known explanation of the difficulty has been offered by Professor Max Müller in the second series of his lectures. He contends that the word originally denoted the oak, but that it was transferred to the beech at the time when the oak forests of Jutland were replaced by beech forests. But this does not account for the fact that the Latin word *fagus* means the beech, for Helbig has shown that the Umbrians had already reached Italy before the commencement of the age of bronze. The bronze age began in Italy earlier than in Denmark, and in the bronze age the oak was still the prevailing tree in Denmark, and was quite unknown in the neolithic age, when the Umbrians, whose language was a dialect of Latin, were already settled in Italy. The word *fagus*, therefore, must have denoted the beech in Latin at a period prior to the change in the forest growth to which Professor Max Müller attributes the alteration in the meaning of the word.

Moreover, a great change in the vegetation of a country, such as the replacement of the Danish oak forests by forests of beech, must have occupied many centuries. At what moment, then, was the name transferred from one tree to the other? Were the people of Denmark content to have no name for the beech when it first appeared, and what did they call the oak after having deprived it of its original title, in the prolonged period during which the two trees must have been growing side by side?

Another hypothesis, less beset with difficulties, has been advanced by Geiger and Fick, who suppose that the word originally signified the beech, and received among the Greeks the changed signification of the oak. If the Greeks had migrated from a land of beeches to a land of oaks there is no difficulty in understanding that they may have transferred the name of one tree to the other. The word, meaning the food-tree (φαγ ἰν, to eat), would be as applicable to the evergreen oak, with its acorns, as to the beech, the mast of which was the staple food for their swine. The beech, as has been said, is not found south of Dodona, which lies in the centre of Epirus. It is noticeable that the most ancient Greek legends are connected with Dodona, where the Greeks made their first halt in their progress to the south, and where the earliest prophetic utterances were obtained from the rustling of the leaves of the sacred tree—the φηγὸς. Hence we may believe that the Greeks entered the peninsula, not from Asia Minor, but from the north-west, through the valleys of Epirus. This route would explain how the old Aryan word denoting the beech came to be applied by the immigrants to designate the tree which flourished on the hill slopes of their new territory. In modern times we have similar instances of transferred names in the United States, where such English names as the robin, the hemlock, and the maple are used to denote wholly different species.

But with regard to the Greeks, it may be urged that before they entered the peninsula they must have been already acquainted with the deciduous oak, which flourishes in the region whence they emigrated. This objection is met by the fact that the Greeks had a second name for the oak, δρῦς, which corresponds to the old Irish *daur* oak, as well as to the Gothic *triu*, and the Sanskrit *dru* which mean simply a tree. Both of the Greek words for the oak are used by Sophocles in speaking of the sacred oak at Dodona.

The Greek word for the deciduous oak agrees with the Celtic word, while the Greek word for the evergreen oak was the word which in their former home had denoted the beech.

The question as to whether the original Aryan word denoted the beech or the oak is not unimportant, as from it may be drawn an inference as to the primitive seat of the Aryan race.

According to Professor Max Müller, the Aryans migrated from Central Asia, where the beech is unknown. If this had been the case it is extremely difficult to explain how the ancestors of the Latins, Celts and Teutons, migrating, as Pictet maintains, at different times and by different routes, to lands where the beech abounds, should all have chanced to call it by the same primitive name; merely modified according to the fundamental phonetic laws of Latin and German. But, on the other hand, all such difficulties disappear if we assume that the cradle of the Aryans was in the original beech region; that is, roughly speaking, in the valleys of the Rhine, the Main, and the Danube; and that it was here that the differentiation of the Greek, Latin, Celtic, and German languages took place.

The name of the beech bears also on the solution of the question as to which of the neolithic races has the best claim to represent the primitive Aryans. The choice probably lies between the brachy-cephalic Celto-Latin race, some of whose earliest settlements may be discovered in the pile dwellings of Bavaria, Switzerland, and Northern Italy, and the dolicho-cephalic Scandinavian race, whose remains are found in the Danish kitchen middens. That one of these races constituted the primitive Aryan race and imposed its language on the other, is highly probable.

Now, as we have already seen, in the neolithic age the beech had not yet reached Denmark, the fir being at that time the predominant tree. In the bronze age the fir was succeeded by the oak, which gave place in the iron period to the beech. Hence the beech region was at that time inhabited by the Celto-Latin people, while the Scandinavian race in all probability dwelt to the north of its limit.

The beech has therefore a threefold ethnological significance.

(1) It proves that the Greeks entered Hellas from the North, probably through Epirus, and not, as has been contended, from Asia Minor.

(2) It proves that the differentiation of the Aryan languages took place not in Asia, but in Central Europe, on either side of the beech line; the Slaves and Lithuanians being to the east of it, the Greeks, Celts, and Latins farther to the west

(3) It makes it probable that the primitive Aryans belonged to the brachy-cephalic Celto-Latin race, and not the dolicho-cephalic Scandinavians.

DRAWINGS OF THE MILKY WAY.

We have been requested to state that some large detailed drawings of the Milky Way, made at Parsonstown by the Earl of Rosse's assistant, Dr. Otto Boeddicker, are at present on view at the rooms of the Royal Astronomical Society, Burlington House, and that an explana-

tory note on the subject will be read at the next (November) meeting of the Society. There are three large drawings in all, one showing a little more than the northern half of the Galaxy down to about 10 deg. to the south of the equator on either side of the map, and two other drawings on double the scale of the first, each representing a half of the part of the Milky Way shown in the first map. Dr. Boeddicker's drawings differ in character from the drawings of the Milky Way which have been made by other observers. Heis and Gould may be said to show the Galaxy as made up of cloud-like lumps or masses of light and curiously shaped areas of fainter brightness, whereas Dr. Boeddicker shows it as composed of whisps and streams of light with very numerous dark channels, having more or less sharply defined edges. Every one must have noticed the great dark channel which divides the Milky Way into two nearly parallel streams from Cygnus to Scorpio; but Dr. Boeddicker sees innumerable smaller channels of a similar character branching away from the main channel and frequently following the central line of outlying streams of nebulous light, which curve so as to include stream lines of brighter stars. If the existence of such curving streams are confirmed by other observers, and by the unerring eye of the camera (which has not as yet given us any trace of the nebulous light of even the brighter parts of the Milky Way) we shall not be able to resist the conclusion that the nebulous streams are associated with, and are not more distant than, the bright stars which lie upon them; and that associated with the Galaxy there are streams of opaque matter, dust clouds or fog-filled space, which cut out the light of the bright streams, and in most cases follow their curvings, so as to lie upon the central parts of the bright streams. A supposition which seems somewhat unlikely.

The production of these maps has occupied Dr. Boeddicker for the last five years. They have evidently been executed with extreme care. The accurate delineation of faint masses of nebulous light is a much more difficult and laborious task than would be supposed by those who have not attempted such work. The relative intensity of the various parts, as well as the shapes of the nebulous structures, have to be continually altered and compared under difficult conditions, and the ultimate result presented to the world generally only represents a small part of the work that has been done.

There can be no doubt as to the importance of the great problem which has been attacked by Dr. Boeddicker and the Earl of Rosse; but it is rather curious that the owner of the largest telescope in the world should have devoted so much of the time of his observatory to a class of work which can be done with the naked eye, and needs no instrument larger than an opera-glass. We shall see what the very numerous owners of such commonplace instruments have to say in confirmation or contradiction of the Parsonstown work. A. C. R.

SOME PROPERTIES OF NUMBERS.

By Robt. W. D. Christie.

It is a fact well known to all who are engaged in the education of the young that the rule of arithmetic known as long division is one of the most difficult to be comprehended by learners; and it has occurred to me that an alternative method of arriving at the same results would be appreciated. The proposed method possesses one or two advantages peculiar to itself. The figures of the quotient are given in the reverse of the usual order, and, when the remainder is known, the quotient is obtained surprisingly quickly. The chief difficulty by this method is to obtain the true remainder, but this is by no means insuperable. I shall first give one or two examples having no remainder, and afterwards deal with the question of remainders. It is to be understood that the method particularly applies to all divisors ending in the digits 1, 3, 7, and 9, and therefore to all prime numbers, and consequently to any divisor whatever, since all numbers are compounded of prime numbers.

Example I.—Find the quotient of 86419753÷7.

Rule.—Multiply both dividend and divisor by 3.

(N.B.—*Three* is the multiplier for all divisors ending in the digit 7. Multiplication is preferable but not absolutely necessary.)

Thus 259259259÷21.

Now multiply this dividend by the tens' digit of the divisor, viz. 2, as follows, and point off the quotient.

25925925.9
18
90.7
14
57.6
12
24.5
10
91.4
8
58.3
6
25.2
4
2.1
2

The quotient required is thus 12345679.

Example II.—Again, find the quotient of

2308576914÷17.

Rule.—Multiply dividend and divisor by 3.

Thus 6925730742÷51.

Now multiply this dividend by the tens' digit of the divisor, viz. 5, as follows, and point off the quotient as before.

692573074.2
10
306.4
20
728.6
30
569.8
40
252.9
45
920.7
35
688.5
25
66.3
15
5.1
5

The required quotient is 135798642.

Though the method is here given at full length, a good deal could, in actual practice, be done mentally. It will be noticed that the figures 69257, &c. are "brought

down" in the *reverse* of the usual order, *i.e.* from right to left instead of from left to right.

EXAMPLE III.—Find the quotient of 733827160503 ÷ 743.

Rule.—Multiply all divisors ending in 3 by 7.

Thus we have 513679012352.1 ÷ 5201.

Now multiply by 520, and point off the answer as before.

```
513679012352.1
          520
       1183.2
       1040
      90014.3
       1560
      8845.4
      2080
     7676.5
     2600
     6507.6
     3120
    13338.7
     3640
    50969.8
    4160
    4680.9
    4680
```

The quotient is 987654321.

It will be observed that there is here nothing "tentative," as in ordinary long division. In fact, the most difficult work required is multiplication by one figure, and I have no doubt that any intelligent child could be taught to find the quotient by this method much easier and more quickly than by the usual one.

EXAMPLE IV.—Find the quotient of 41107567 ÷ 9001.

Rule.—Divisors ending in *unity* need no multiplier. Therefore × by 900.

```
411.0756.7
      6300
  410445.6
     5400
   40504.5
    4500
    3600.4
    3600
```

The quotient is 1567.

EXAMPLE V.—Find the quotient of 2929559 ÷ 389.

Rule.—Multiply divisors ending in 9 by 9.

Thus 26366031 ÷ 3501.

Now multiply by 350, and point off the quotient as before.

```
2636603.1
      350
   3625.3
   1050
   6257.5
   1750
   2450.7
   2450
```

The required quotient is 7531.

I have now given all the varieties which will be required, viz. divisors ending in 1, 3, 7, or 9.

In a future paper I purpose, with your kind permission, giving a few further particulars showing the adaptability of the method to all divisors whatsoever.

COLOUR BLINDNESS.

By RICHARD BEYNON.

THE first prominent case of colour blindness of which we have authentic record is that of John Dalton, the propounder of the Atomic theory. Although in his Lectures on Natural Philosophy he had discoursed on the "Doctrine of Colours," Dalton did not discover his own infirmity until a later date, and then quite by accident. The blooms of the geranium appeared to him a different colour by candle-light than by day. In spite of the assurances of his friends that the vivid red of the flowers was constant, to him the blooms were sky-blue by day and red by candle-light. From this discovery he was led to investigate the peculiarity of his own colour vision by means of the solar spectrum. As a result of his researches he clearly demonstrated that there are some people who experience the same sensation of colour from two such opposite colours as red and green. From the date of Dalton's discovery in 1794 down to a few years ago, very little light was thrown upon the apparent vagaries of this disease. It is true that several treatises were written on the subject, but they treated colour blindness rather as a rare and curious phenomenon than a malady which had any practical bearing upon the relations of every-day life. In the year 1877 public attention was directed in a very forcible manner to the practical issues hinging upon colour blindness. In the December of 1876 the railway accident commonly known as the Arsley Junction Disaster occurred, caused by the inability of a responsible person to discriminate between red and green signal lights; and then a series of letters and articles appeared in the *Times* drawing public attention to the great importance of this subject, and as a result the Board of Trade inaugurated compulsory tests for those engaged in the Mercantile Marine as to this visual defect. There seem to be three primary colour sensations which give rise to all other sensations of colour—these are red, green, and violet. The person who is not colour blind can perceive with the central portion of his retina all three of these colours. In a zone outside this, red is not seen; and in a zone outside of this again both red and green fail us, and we can perceive only blue or violet. Colour blindness is the failure of one or more of these three sensations. A person may be blind to red, to green, to violet, or to all three. The first two, however, involve each other, for a person blind to red is also blind to its complementary green. Blindness to violet includes blindness to yellow also, but this phase of the disease is very rare indeed. It must not be supposed, however, that a person blind to red sees green as a person possessed of normal vision does; he sees both red and green as greyish, and, in proportion as he is colour blind, all colours containing red and green will appear as if so much grey, or white and black mixed, had been used in producing the colour, instead of the ordinary red and green pigments. Colour-blind subjects instinctively and of necessity learn to judge of the colour of light by its intensity. Cases of total colour blindness, in which the person is devoid of all colour perception and sees coloured objects merely as shades of black and white, are exceedingly rare.

Examinations of males and females of all races and ages prove that about 3·5 of the former and 1·5 of the latter are afflicted with colour blindness.

Professor Holmgren, of Upsala, examined 32,165 men and found 1,019 or 3·16 per cent. colour blind. Of 18,556 men tested by Dr. Joy Jeffries, of Boston, Mass., 764 or 4·11 per cent. were colour blind.

The London Committee for investigating the prevalence

Distant View of the Lick Observatory, Mount Hamilton.

View from Mount Hamilton over Sea of Cloud.

of colour blindness found 617 colour-blind people, or 4·156 per cent., out of the 14,846 examined by them. Dr. Bickerton, among 3,087 men tested by him, discovered that 105 or 3·40 per cent. were suffering from this visual affliction.

The method of examination in all cases was that recommended by Professor Holmgren. It consists in each individual picking out from a large number of differently coloured wools all those skeins which have in them any tint of the particular test colour placed before him. The large majority of people would pick out to the very last every skein which had any tint of green in it, no matter how delicate; but a certain number would choose some colour, such as grey, yellow, or red, to match with the green, or they would omit to pick out the greens. In this manner their weakness of colour perception would betray itself to the examiners, who would then proceed to apply, under the same system, still more crucial tests. That colour-blind tests should be absolutely fair to the tested one, it is of the highest importance to distinctly observe the difference between the manner in which the colour-blind *sees* and the manner in which he *names* colours. The sensation is based upon the nature of the sense of colour in the organisation of the optic nerve from birth. The name, on the contrary, is learned. It is purely conventional, and depends upon exercise and habit. The names of colours are naturally the objective expression of subjective sensations. They are regulated by the system of the normal sight, and cannot, consequently, agree with that of the colour-blind. They can nevertheless be learned by the latter, and even applied correctly in many cases. It is no doubt under this veil that many colour-blind subjects unconsciously conceal their infirmity from themselves and their most intimate friends. Hardly any limit can be set to their capacity for learning other attributes of coloured objects, and of recognising and remembering their colour names through these alone. Thus they deceive themselves that they have gained by *practice* a colour perception they were not born with. Persons afflicted with colour blindness have been known to succeed as landscape and portrait painters; but then their colours must either be marked or chosen for them, or detection of their failing may ensue. A student of the Royal Academy who was selected, not only by the authorities, but also by his fellow-students, as having the best perception for form and power of light and shade, turned to the use of colours. In this branch of his art it was naturally supposed that he would also exhibit talent. He was allowed to take a portrait by Titian from the National Gallery, and have it in a small room by himself. There he copied it to the best of his ability, and, as he stated to the Principal and his brother students, no one visited him while he was at his work. His result was the most perfect copy, as far as light and shade went—but all shades of green had been used.

The consensus of medical opinion goes to prove that colour blindness is congenital and hereditary. Children born with it do not grow out of it as they rise in years, nor can the defect be palliated by any practice with colours. It has been shown that this visual defect is subject to the general laws that govern the transmission of hereditary disease from one generation to another. In the ordinary walks of life a man may go through life colour blind merely at the cost of inconvenience and discomfort to himself. But on the ocean and the railway, where safe locomotion is always dependent upon the ability of the look-out to discriminate immediately and correctly between red and green signal lights, every degree of chromatic defect is dangerous alike to life and property. But of this aspect of the colour-blind question and its close relation to the Mercantile Marine, I propose, if the Editor will permit, to write on a subsequent occasion.

Persons cannot be tested for colour blindness too early in life. The tests now employed are of such a simple character that they might with very great anvantage be introduced into our public schools; and many a lad would be spared the mortification of discovering in later life that he has embraced a calling continuance in which is fraught with terrible risk and danger to the lives and property entrusted to his care.

ON LARGE TELESCOPES.

By A. C. Ranyard.

It is now more than two centuries and three quarters since the imagination of man was first stirred by the invention of an instrument which enabled him to magnify the face of the heavens. He had from a very early date—from Assyrian times at least—possessed lenses which enabled him to magnify the minute things about him to a small extent, and to see somewhat more of their beauty than he could detect with the eye alone. But the invention of the telescope in the first decade of the seventeenth century, or, more accurately, the use to which Galileo put the new-found treasure, revolutionized philosophy. It was a poor little instrument which Galileo possessed, giving very little light and a great deal of colour. Though his best telescopes magnified thirty-two or thirty-three times, the sharpness of their images must not be compared with a modern achromatic of similar power. Since the days of Galileo, it has been the constant ambition of many minds to devise means which would enable us to peer further into space. The progress was at first very slow, longer and longer telescopes were used, till instruments of over 200 feet focal length were employed; they had, of course, no tube. The object glass was pulled up and down the side of a mast, and the observer stood on the ground with the eye-piece held to his eye, and a string in his hand to turn the object glass towards him. Even in still weather such telescopes must have been very difficult to use with the constant varying height of the object above the horizon, and the shifting of the object glass and observer necessary to keep the object in focus. But with such an instrument (of $212\frac{1}{4}$ feet focal length) Bradley measured the diameter of Venus in 1722; and Casini observed the great division in Saturn's ring, and four of his satellites. Titan, the largest of the satellites, had been discovered in 1655, with a 12-foot tube, by Huyghens.

The first material step in advance was due to the suggestion of a Scotchman, James Gregory, who, in his *Optica Promota*, published in 1663, proposed that the rays of light from a remote object should be received by a concave parabolic speculum and be reflected back by a smaller elliptic speculum through a hole in the centre of the larger reflector; but he failed in his attempt to obtain a sufficiently true parabolic figure. And the first person who actually succeeded in making a reflecting telescope was Sir Isaac Newton. Although this invention got rid of the chromatic difficulty (for rays of all colours are brought to the same focus by a reflector), very little astronomical work was accomplished with the new instrument of research until after the invention of the achromatic telescope, the idea of which had been conceived by Newton. But owing to a curious mistake in an experiment the cause of which is involved in mystery, he not only did not invent the achromatic telescope, but he went so far as to predict that such a telescope never could be

made. The great authority of Newton no doubt checked experiment in this direction for a generation, and the mistake is much to be regretted. In his *Optics*, Book I., Part II., Experiment 8. Newton says :—"I found, moreover, that when light goes out of air through glass, and thence goes out again into air, whether the refracting superficies be parallel or inclined to one another, that light as often as by contrary refractions 'tis so corrected that it emergeth in lines parallel to those in which it was incident, continues ever after to be white. But if the emergent rays be inclined to the incident, the whiteness of the emergent light will by degrees in passing on from the place of emergence, become tinged in its edges with colours. This I try'd by refracting light with prisms of glass placed within a prismatic vessel of water." From this Newton concluded that no combination of lenses of different refractive index would bring light to a focus without separating different colours of the spectrum in the same way as they are separated by a single lens.

It was not till 1729, two years after the death of Newton, that Mr. Chester Moor Hall, a young barrister of the Inner Temple, succeeded in combining two lenses of different sorts of glass so that they gave colourless images. It is known that he constructed several achromatic telescopes, one of two and a half inches aperture and only twenty inches focal length, which was in existence in 1790. But how he arrived at his invention, whether experimentally or deductively from experiments with prisms, is not known. No use of this new and important weapon for astronomical discovery was made for more than a quarter of a century, and the invention had been forgotten, or perhaps it was not ever known to any very wide circle. At all events, it cannot kave been known to the members of the Council of the Royal Society, who, thirty-two years after, in 1761, awarded medals, and distributed the patronage of English science. For they then gave the Copley Medal to John Dollond for a similar discovery, of which he had seen the commercial value, if not the astronomical use.

John Dollond was a Spitalfields weaver. He was born in 1706, and at the age of forty-six, having set up his son as an optician and joined him in the trade, he commenced experiments with prisms for the purpose of testing the truth of the statement of Newton quoted above. Having found that Newton was mistaken, he set himself to combine suitable lenses of different refractive index, and made an achromatic telescope. This is the story as given by Dollond himself in a paper published in the *Phil. Trans.* of the Royal Society. On the 19th of April 1858, he took out a patent for his invention, which eight years afterward was disputed in a Court of law; for the patent had become valuable, and other opticians, hearing of Moor Hall's discovery, had begun to pirate it. Champness, an optician in Cornhill, was proceeded against, and he brought workmen into court who proved to the satisfaction of Lord Mansfield that, twenty-five years previously, they had made similar instruments for Mr. Moor Hall. Lord Mansfield upheld the patent, remarking that "It was not for the person who locked up his invention in his scrutoire to profit by it, but he who brought it forth for the benefit of the public."

I hope that it will not be thought that I wish to throw any doubt on the genuineness of Dollond's discovery. I believe this to be one of the very numerous duplicate discoveries which may be quoted in the history of science. Their existence is almost as remarkable as the number of double stars, and the duplicity of so many lines in the spectrum—there must be some reason for it. It is not so strange a phenomenon when we regard a discovery as the last and most fruitful step in a chain of thoughts, many of which are the common property of the age in which the discoverer lives. We are too apt to look at discoveries as the sole production of one mind. That John Dollond was an independent thinker and worker is, I think, sufficiently proved by other things known about him. He is said to have died from a fit of apoplexy, brought on by intense application in studying Clairaut's Theory of the Moon. From the time of Dollond onward the refracting telescope went on improving; but great strides were made, towards the end of the century, in the construction of reflecting telescopes, especially at the hands of Short and Sir William Herschel.

The reflecting telescope is, to a great extent, a creation of English growth. It has been the favourite instrument of English amateur astronomers. Sir William Herschel, Sir John Herschel, Lassell, the Earl of Rosse, Common, and Isaac Roberts have all most successfully used reflectors, and with the exception of Mr. Roberts they have all made their own instruments. Reflecting telescopes have not been received with such favour abroad, or even in America. With the exception of a 28-inch reflector, made by Dr. Henry Draper, no large reflectors have been used in America, and very few on the Continent of Europe. The reflecting form of telescope has been chosen by the great amateur astronomers (who have done so much towards the progress of astronomy), probably because it is less costly to make than a refractor of equal aperture, and there seems to be no limit to the size of the reflector except the mechanical difficulties involved in its construction, whereas with the refractor we are fast approaching the practical limit of size. If you double the diameter and focal length of a refractor you quadruple the amount of light that is lost by absorption in the object glass; thus the thickness of the crown glass lens of the great Washington 26-inch refractor at its centre is 1·88 inches, and the thickness of the flint - glass lens is 0·96 inches, making together a total thickness of glass of 2·87 inches. Even with the clearest glass manufactured, more than half the light which falls on such a thickness of glass is absorbed in passing through it. If we double the thickness, more than three-quarters of the light would be absorbed, and less than one quarter would be transmitted; for the first half of the thickness halves the light, and the second half halves it again. The greatest loss of light is only for the centre of the object glass; but in all parts the absorption is quadrupled for a lens of double aperture. It will thus be seen that we are rapidly advancing towards the limit where an increase of size with the refractor will not give us an increase of light. But with the reflector the whole of the light reflected reaches the eye-piece, whatever is the size of the instrument. The difficulties which set a limit to the size of the reflector are chiefly mechanical. If the aperture of an instrument is doubled, and the same proportions are kept, the weight of each part of the instrument is multiplied by eight. We have not yet approached the proportions of the Eiffel Tower, or the Forth Bridge; but it is not to such immense increases of size that I look for progress in our knowledge of the Universe. It is rather to the increased sensitiveness of photographic plates, and to improvements in the driving, accurate figuring, and mounting of telescopes. It has always been acknowledged that the most important part of an instrument was the man at the eye-piece end. And in this day of large instruments the relative importance of the man is becoming greater and greater.

The great variety as well as complication of the appliances which are now-a-days supplied to the Observer by the Engineer may be judged of by our Frontispiece of

the eye-piece and of the great Lick 36-inch refractor. As in the case of Galileo and Dollond, it is the man who makes use of the idea or the tool at his command who makes the greatest progress, and leaves the greatest legacy to mankind.

We owe the pictures of the Lick Observatory with which this article is illustrated to Mr. Barnham, who is now on his way to Trinidad to observe the eclipse of the sun.

BARNACLES.

By S. Heywood Seville.

Amongst the curious myths which in the middle ages did duty for natural science, one of the longest-lived, and yet one of the most extraordinary, was that which not only conceived the common shell-fish the barnacle to be the fruit of a tree, but went on to allege its transformation into the sea-bird known as the barnacle goose. The successive changes from fruit to fish, and from fish to fowl, which the myth involved, proved no obstacle to its wide acceptance and long-continued credence. It was widely current before the end of the twelfth century. Giraldus Cambrensis, writing in the reign of Henry II., gives in his *Topographia Hiberniæ*, a detailed account of it. "There are in this place," says he in one passage, "many birds which are called Barnacles; against nature, nature produces them in a most extraordinary way. They are produced from fir timber, tossed along the sea, and are at first like gum. Afterwards, they hang down by their beaks as if from a sea-weed attached to the timber, surrounded by shells in order to grow more freely. Having thus, in process of time, been clothed with a strong coat of feathers, they either fall into the water or fly freely away into the air. They derive their food and growth from the sap of the weed or the sea by a secret and most wonderful process of alimentation. I have frequently with my own eyes seen more than a thousand of these same bodies of birds hanging down on the seashore from one piece of timber, enclosed in shells and already formed. They do not breed and lay eggs like other birds, nor do they ever hatch any eggs, nor do they seem to build nests in any corner of the earth." After this account Giraldus proceeds to inveigh against the custom, which prevailed in some parts of Ireland, of eating the barnacle geese during Lent—a custom which was justified by those who followed it by the argument that the geese were "not flesh nor born of flesh," and which affords striking proof of the credence accorded to the story.

Though contradicted from time to time by some of the bolder writers and observers, the fable kept a strong hold on the popular mind, and even the educated were not ashamed to avow their belief in it. Sir John Maundevile alludes to it in his *Travels*, where he speaks of the "trees that bear a fruit that becomes flying birds." Sir John somewhat naively adds that the people "towards Upper India," to whom he recounted the story, "had thereof great marvel that some of them thought it was an impossibility." The *Travels* appeared about 1370, and more than two centuries later the subject was treated with considerable fulness and in the most obvious good faith by John Gerarde, who, in his *Herbal*, published in 1597, devotes to it a chapter entitled "Of the Goose-tree, Barnakle-tree, or the tree bearing Geese," in which, after narrating the current belief as to the barnacle geese being produced in the North of Scotland from shell-fish growing on trees, he proceeds to pledge his own credit as to the main facts of the story. Clearly, the myth was current in Shakespeare's time, and, although in an edition of the *Herbal*, published in 1636, the editor added a note of caution to the reader at the foot of the chapter, yet eighty years after Gerarde wrote, a scientific writer was to be found, who, writing for scientific readers, asserted, of his own knowledge, the existence of the birds within the shells. This was Sir Robert Moray, who describes himself as "lately one of His Majesty's council for the Kingdom of Scotland," and who contributed to the *Philosophical Transactions* of 1677-78 a paper entitled "A Relation Concerning Barnacles," from which the following passages are transacted:—"Being in the Island of East, I saw lying upon the shore a cut of a large fir-tree, of about 2½ foot diameter and 9 or 10 foot long, which had lain so long out of the water that it was very dry; and most of the shells that had formerly covered it were worn or rubbed off. Only on the parts that lay next the ground there still hung multitudes of little shells, having within them little birds perfectly shaped. . . . The shells hang on the tree by a neck longer than the shell; of a kind of filmy substance, round and hollow, and creased, not unlike the windpipe of a chicken, spreading out broadest where it is fastened to the tree, from which it seems to draw and convey the matter which serves for the growth and vegetation of the shell, and the little bird within it. . . . This bird in every shell that I opened, as well the least as the biggest, I found so curiously and completely formed that there appeared nothing wanting as to the internal parts for making up a perfect sea-fowl; every little part appearing so distinctly that the whole looked like a large bird seen through a concave or diminishing glass, colour and feature being everywhere so clear and neat. The little bill like that of a goose, the eyes marked, the head, neck, breast, wings, tail, and feet formed, the feathers everywhere perfectly shaped and blackish coloured, and the feet like those of other water-fowl to my best remembrance."

Such was the old belief existing during five centuries at any rate, and probably accepted at periods both earlier and later than those from which the preceding examples are taken. To modern observers it seems utterly absurd. Science has shown its absolute groundlessness as natural history, and Professor Max Müller, to complete the rout, has put forward in his "Lectures on the Science of Language," a very interesting theory of its probable origin from the point of view of philology. But the latest researches have shown that the barnacle has been deposed from his place in a mythical metamorphosis only to take part in his life-history as now ascertained in another transformation scene quite as wonderful, and this time vouched by the careful observations of our best naturalists.

In the adult state the barnacle consists of a shell-fish permanently attached by a fleshy peduncle or stalk to a piece of timber or rock or some other object in the sea. The shell opens by a peculiar valve-like arrangement, and, through the aperture thus formed, several pairs of long, many-jointed "cirri" or feelers are put forth, which, by their constant waving motion, whirl to the creature's mouth the small particles which form its food. Huxley's description is concise and expressive: "A crustacean fixed by its head, and kicking the food into its mouth with its legs." It is not the change of this creature into a goose that science can now surprise us with; that story must be given up along with the accounts of griffins, phœnixes, and dragons. The fruit theory as to its origin must also be abandoned, but though the new account does not involve quite so violent a transition as that from the vege-

table to the animal kingdom, it is still in the steps by which the adult form is reached that those changes are revealed which almost entitle the barnacle to the reputation for facile metamorphosis with which our forefathers credited it. The steps in question are (besides the egg) the two stages know respectively as the *Nauplius* and *Cypris* stages. Immediately on its escape from the egg the young barnacle appears as an animal of microscopic size, active and free-swimming, equipped with a broad shell or shield on its back, and having three pairs of legs, a single eye, a mouth and a forked tail. This is the *Nauplius*, and in outward appearance the young creature exhibits at this stage no single point of resemblance to the parent form. It feeds and grows apace, and moults several times. It then enters the next condition of its existence—the *Cypris* stage. The broad shield-shaped carapace becomes folded together, somewhat after the pattern of a bivalved shell, and almost encloses its owner. The foremost limbs are transformed into a very peculiar pair of suctorial or adherent feelers, and the two hinder pairs are cast off, their place being taken by *six* pairs of powerful swimming-legs with bifid extremities. A pair of compound eyes is another new feature of this stage, and altogether the *Cypris*, while still quite distinct from the adult barnacle, presents a very different appearance from the *Nauplius*. The mouth is wanting, or at least is functionless, being covered by an integument without aperture. Existence in this stage is therefore necessarily short, and the *Cypris* soon fixes upon its future abode by attaching itself by its suctorial feelers to some piece of drift-wood, pile, or rock. A kind of cement, which it secretes by means of special glands, pours out round the base of attachment and quickly hardens, gluing the ends of the feelers firmly to the surface on which they rest. The compound eyes are shortly afterwards moulted; the body straightens out, and the shell thus comes to stand almost perpendicularly to the surface of attachment. Other changes follow: the shape of the shell is modified, and the position of the animal within alters in such a manner that the under surface of its body is turned directly away from the point of attachment; the integument covering the mouth is cast off; the legs cease all swimming ambulatory functions, and soon become mere cirri sweeping the water for prey; the feelers are gradually covered with a fleshy pulp, and, losing all trace of their old form, are converted into a single stalk of attachment; the new parts of the shell which are to form the valvular opening and other protecting plates begin to form, and, for all practical purposes, the barnacle, though still very minute, has attained its adult form, future development being mainly in the matter of size.

The old legend involved a double change from fruit to fish, and from fish to bird; the new history also deals with a double change, from *Nauplius* to *Cypris*, and from *Cypris* to barnacle. For one series of wonders another has been substituted, and, if this is not sufficient to restrain us from too hastily condemning our forefathers' credulity, it will be well to remember how recently we have arrived at the truth. Little more than fifty years ago the position of the barnacle in the animal kingdom was still completely unsettled. Agreeing in most of its outward characteristics with the mollusca, it was commonly classed with them. The *Nauplius* and *Cypris* were not connected with the parent form, but, if described at all, were treated as distinct animals. In 1830 J. Vaughan Thompson's description of his observations of their metamorphoses cast a new light on the subject, but the question still remained somewhat open ground for naturalists, and it was not until 1851–53 that Darwin, in his *Monograph of the Cirripedia*, definitely settled the barnacle's claim to be classed with the crustacea, and established beyond dispute the facts of its complicated and peculiar life-history.

Dr. Huggins has recently succeeded in obtaining a satisfactory photograph of the spectrum of Saturn and its rings. He states that the exact correspondence of the Fraunhofer lines in the spectrum of the sky (*i.e.* in the solar spectrum), and in the spectrum of the body of the planet and its rings, is clearly shown. He is unable to detect any lines, either bright or dark, which are not present in the solar spectrum. He has obtained a similar result with the spectrum of Uranus.

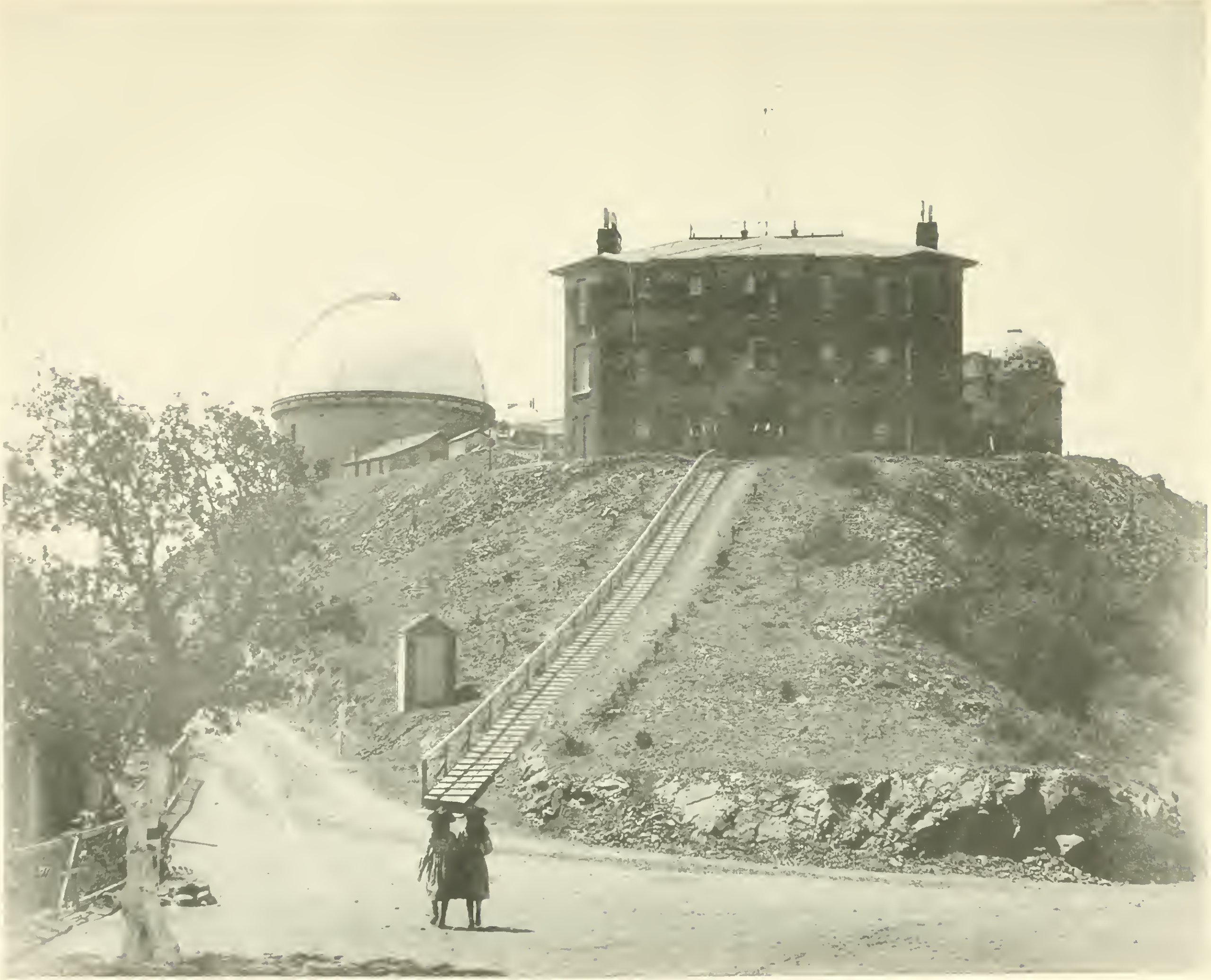
A memoir of Dr. Henry Draper has just been published by his friend, Prof. G. F. Barker.

Notices of Books.

A Text-Book of General Astronomy. By Chas. A. Young, Ph.D., LL.D., Professor of Astronomy in the College of New Jersey. (Boston, U.S.A., and London: Ginn & Co.)—A second edition of this valuable book has been called for within six months of the publication of the first edition. To call it a text-book is almost misleading. It is rather an encyclopædia than a text-book, for it contains information on a very wide range of subjects connected with physical, as well as general, astronomy, arranged in numbered paragraphs under well-chosen headlines, and the whole is referred to by a copious index. Many of these paragraphs are admirable specimens of condensation, but the art of abbreviation has not been carried too far; the explanations remain lucid, and adapted, as Prof. Young desires they should be, to the comprehension of any "liberally educated person"; they require, in fact, a knowledge of elementary algebra, geometry, and trigonometry. It is refreshing to find such a liberal use of the term "liberally educated." On this side of the Atlantic the phrase "a liberal education," as well as the terms "scholar" and "a man of scholarship," only convey to most minds an idea of classical erudition; but we are, perhaps, a little in advance of the language we use. Prof. Young's book ought certainly to be understood by an intelligent school-boy. It would be impossible to treat so large a subject without making some statements which might be criticised, and without laying oneself open to the charge of having dealt with many subjects which are of less importance than others that have been omitted.

Prof. Young has treated his own especial subject, the sun, very meagrely. The polarised condition of the light of the corona is not referred to. The remarkable connection between the general form of the corona and the development of sun spots is not noticed, nor is the remarkable bending together of coronal structures into groups referred to. Only one picture of a corona is given, and that is wrongly oriented. It has its north pole where its eastern equatorial region ought to be. Curiously, the same mistake is made with regard to the same picture in the last edition of *Chambers' Handbook of Astronomy*, p. 486. Probably both mistakes are due to a mistaken orientation of a woodcut in an early number of Knowledge, which was one of the first pictures of a photograph of the corona taken during the eclipse of 1882 that was published. According to it, the comet "Tewfic," which was seen near to the sun during the Egyptian eclipse, was moving in an easterly direction, instead of northward, nearly at right angles to the ecliptic.

Prof. Young estimates the growth of the earth, due to



Dome of the Great Equatorial of the Lick Observatory, and Observer's House.

the fall of meteoric debris, as amounting to a layer of only about an inch thick in a thousand million years, an amount which may be practically neglected in considering geological and physical problems. His estimate is founded on Prof. Newton's well-known estimate of the average number of visible meteors which fall daily over the whole surface of the earth, but this leaves out of consideration telescopic meteors, and meteoric dust, which may fall without even being visible in the telescope. The number of telescopic meteors must be enormous compared with the number of visible meteors; for no one can observe for many hours, with a low power and a field 10′ or 15′ in diameter, without seeing several of them flash across the field. Prof. Young's assumption with respect to the average weight of luminous meteors is founded on some observations by Thomson, of Copenhagen (made thirty years ago), which connect the luminous energy of a standard candle with foot pounds. The assumptions which it is necessary to make in order to connect the momentum of a meteor with the light it gives out, as it is broken up by impact with the earth's atmosphere, are necessarily very wide. Probably a better idea as to the size of a meteoric particle capable of giving the light of a sixth magnitude star may be derived from the consideration that a standard candle, seen at the distance of a mile, is only a little brighter than a first magnitude star. Consequently, without taking atmospheric absorption into account, an incandescent body, at a distance of 100 miles, would only appear as a sixth magnitude star if it shone with a light about equal to that of an electric lamp of 100 candles power. As only the larger meteors enter the earth's atmosphere to a depth of below 70 miles above the surface, it may be assumed that few of the meteors seen, except those which appear near to the zenith, are within 100 miles of the observer. One may, consequently, pretty safely assume that a meteor which is just visible to the naked eye is larger than the portion of the carbons rendered incandescent in an arc light capable of giving 100 candles' power. For a mass of carbon, such as is used for electric lighting purposes, gives off more light while being driven into vapour than other substances which have been experimented upon; and the carbon of the electric light is not exposed to the tremendous bombardment of cold air, which must tend greatly to accelerate the disintegration of the meteoric masses in their passage through the air, as well as to cool their surface by removing the incandescent matter as rapidly as it is formed. Added to this, Prof. Newton's estimate of the average number of visible meteors which fall in a day, is made on the assumption that an observer at any station can see meteors which fall at a distance of 300 miles.

It would be an advantage if in future editions Professor Young would give more references to the places where the original papers referred to may be found. In many instances it is difficult, with the aid of the Royal Society Catalogue, to trace the memoirs referred to, and in the case of many investigations by American observers it is impossible from the mere name of the author to trace the paper referred to. The book is well illustrated, and in most instances the diagrams are original and well contrived. With all the advances that America has made, authors have more to contend with in the land of Franklin then they have here. The number of printer's errors must have been very annoying to Professor Young. This has, however, been greatly improved in the second edition.

Professor Young is an accomplished practical astronomer, and a teacher of great experience, as well as a popular exponent of science in lucid and simple language. He is also a man of wide reading, and the combination has given us an astronomical text-book of exceptional value.

A Hand-book of Descriptive and Practical Astronomy. By George F. Chambers, F.R.A.S., Barrister-at-Law, &c. &c. (Printed at the Clarendon Press, Oxford, 1889.)—We have received the first instalment of a Fourth Edition of this useful hand-book, which has now so grown in bulk that it will occupy three large octavo volumes, which will be sold separately. The first volume now published is devoted to the Sun, the Planets, and Comets. The second volume, which it is hoped will be published at the end of this year, will be devoted to "Instruments and Practical Astronomy"; and the third, which will probably appear in 1890, will refer to the Stars and Nebulæ. The valuable chapters on comets and the list of cometary orbits and other cometary statistics given in former editions have been brought up to date, and materially enlarged and improved upon. There is no other work published in England which contains so many cometary statistics and so much information with respect to the forms of cometary envelopes and jets. The chapters on meteoric astronomy and aërolites have been revised by Mr. Denning, and will well repay careful perusal. In the chapter on total solar eclipses, Mr. Chambers has reprinted the most important parts of Mr. W. H. Wesley's valuable paper on the structure corona, which was first published in the *Monthly Notices*. Mr. Wesley has brought the review of coronal photographs up to date for Mr. Chambers, and has given outline drawings of coronal photographs from 1851 to the eclipse of 1887. This affords a wider field for comparison than has hitherto been laid before the public.

The Story of a Tinder-Box. By Chas. Meymott Tidy, M.D., M.S., F.C.S., &c. (Society for Promoting Christian Knowledge. 1889.) This is a delightful little book, written in the plainest untechnical language. It is stated to be a reprint of holiday lectures delivered to young people (evidently at the Royal Institution, though the place of delivery is not mentioned). The book contains a great deal of information with respect to the history of matches, tinder boxes, flints and steels, Davy lamps, and such common things. Dr. Tidy seems to have been very fortunate in bringing together for his audiences a collection of tinder-boxes, old "Sulphur matches," "Chemical matches," which were invented in 1807; they were tipped with a mixture of chlorate of potash and sugar, and were fired by dipping them in a bottle containing asbestos moistened with sulphuric acid. The original "Lucifers," invented in 1826, which were tipped with a mixture of chlorate of potash and sulphide of antimony, and were lighted by drawing them through a little piece of folded glass paper; "Prometheans," and other early forms of matches. The tinder-box, however, seems to have held its own till 1833, when it was discovered that bones could be made to yield large quantities of phosphorus at a cheap rate. Up to that time phosphorus (which had been discovered more than a century and a half previously) had been sold at 50s. an ounce. The phosphorus match immediately came into general use, and the reign of the tinder-box ceased about four years before the reign of Queen Victoria began.

Timber and Some of its Diseases. By H. Marshall Ward, F.R.S. (Macmillan & Co.) About eighteen months ago Prof. Marshall Ward contributed to *Nature* a series of articles on certain diseases of timber produced by parasitic fungi, and these have been expanded into the present volume of some 280 pp. The book practically consists of two parts, the first treating of the structure and classification of timber and the method of its formation and growth, and the second dealing specially with fungoid parasites by

which both living and dead wood are attacked, probably to a much larger extent than is generally imagined. The subject is one so new to the English reader, and yet so intrinsically important, and one withal which raises so many interesting biological questions, that this masterly exposition of it cannot fail to be welcomed as one of the most valuable additions to recent popular scientific literature. The chief facts connected with the microscopical structure of the different parts of a tree-trunk are dealt with in two explanatory chapters (one on the wood, the other on the cortex and bark) in so remarkably lucid a manner that no one need plead the scantiness of his botanical knowledge as an excuse for not reading the book. The woodcuts are both numerous and excellent, and several of them represent specimens from the classical series prepared by Prof. Hartig for the Museum of Forestry at Munich, an institution lately visited by the author. A long and rather difficult chapter has been added on the perplexing question of the cause of the ascent of sap in tall trees, and gives, for the first time in an English work, an epitome of the various modern theories on the subject, together with an account of the progress of the controversy during the last thirty years. As a good knowledge of the fundamental laws of physics is requisite for the mastery of this chapter, it will probably present difficulties to the general reader; but, as it is quite complete in itself, it may be passed over by those who desire to do so, without detriment to the rest of the work. In connection with the diseases of timber the main point emphasised by the author is "the destructive action of mycelia of various fungi, which, by means of their powers of pervading the cells and vessels of the wood, and of secreting soluble ferments which break down the structure of the timber, render the latter diseased and unfit for use." The chapter on "dry rot" deserves the closest attention of all who have any responsibility in connection with house property, and the warning held out concerning the danger of leaving the cut base of a branch on a growing tree exposed to the attacks of micro-fungi, claims thoughtful consideration on the part of all who are interested in forestry.

Harvey on the Circulation of the Blood. Edited by Alex. Bowie, M.D. (George Bell & Sons.)—The depths of error and misconception which existed at the commencement of the seventeenth century as to the functions of the heart, and from which William Harvey did so much to rescue medical science, together with the means by which he arrived at his splendid generalisation, have hitherto been known only to the few, and therefore the publishers of "Bohn's Select Library" have done well to add this volume to their series, thus rendering easily accessible to the public the details of that great discovery. The reader is here presented with a translation of Harvey's original Latin treatise "On the Motion of the Heart and Blood in Animals," and of his two "Disquisitions on the Circulation of the Blood," addressed to Riolan of Paris, in answer to objections. The translation is a revision of Willis's edition, published forty years ago under the auspices of the Sydenham Society. To this Dr. Bowie has prefixed an interesting biographical notice of the "simple, modest" little professor, the announcement of whose discovery so startled the world of his day that twenty years afterwards he was able to exclaim, "Scarcely a day, scarcely an hour has passed since the birthday of the Circulation of the Blood that I have not heard something for good or for evil said of this my discovery." At a time when the authority of the ancients was still paramount, and "the divine Galen" was venerated as an oracle, it needed no little hardihood to give to the world a book so revolutionary in its ideas, and even the prestige of his position as Court physician did not avail to protect the author from detraction, for he is himself reported to have said that, "After his book came out, he fell mightily in his practice; 'twas believed by the vulgar that he was crackbrained, and all the physicians were against him." Believing that the intimate connection of the heart with the lungs in the human subject was one of the chief causes of the prevalent misconceptions of the functions of those organs, he condemned strongly those anatomists who "confine their researches to the human body alone, and that when it is dead." He was thus led to pay great attention to comparative anatomy, expecting by the dissection of other animals in which the organs are placed in different relative positions to get at the truth, and this notwithstanding the sneers of those "who derided the introduction of frogs and serpents, flies, and others of the lower animals upon the scene, as a piece of puerile levity." How fully he was convinced of the supreme value of the experimental and inductive method is evident throughout; the most advanced scientist of the present day could not express himself more strongly than this: "I profess both to learn and to teach anatomy, not from books, but from dissections"; or again, "Our first duty is to inquire whether the thing exists, before asking why it exists." By acting on such principles he was able to demonstrate that the heart was the great propeller of the blood instead of the "generator of vital spirits and of heat," and that the veins and arteries were equally portions of the route taken by the whole of the blood in its circular course through the body, instead of being intended, the former to contain most of the blood, and the latter only a little, and that mixed with air and "vital spirits." Enough has, it is hoped, been said to show that this book contains much that is of interest, not merely to the technologist, but to any and every one who cares to inquire into the history of the conquests of science.

The Zoo. Second Series. By the Rev. J. G. Wood. (Society for Promoting Christian Knowledge.)—A capital book for children. It is admirably arranged with letterpress and illustrations judiciously combined, so that every page contains a picture, either plain or tinted. As these are by Harrison Weir, and many of them represent spirited scenes in animal life, there is no chance of the young people's interest flagging. The present series illustrates the Weasel family, Seals, Rodents, and Oxen, and the descriptions, by the late Rev. J. G. Wood, contain just the sort of information children delight in.

How to Teach Arithmetic. By T. J. Livesey. (Moffatt & Paige.)—This little book consists of a series of notes of elementary lessons on Arithmetic, from Numeration and the use of the Abacus to Proportion and some of its more important applications, intended to show the teacher how to lead his pupils to a comprehension of the *rationale* of the various "rules." The fact that it has reached its ninth edition seems to indicate that it has been found useful by many persons, chiefly, it may be presumed, amongst the ranks of junior pupil teachers. The methods advocated are sound, and if the book has a fault, it lies in prolixity, and in the fact that so very little is left for the intelligence of the teacher himself to supply.

The Rotifera, or Wheel Animalcules. (Supplement.) By C. T. Hudson, LL.D., F.R.S., assisted by P. H. Gosse, F.R.S. (Longmans, Green and Co.).—The present issue forms the completion of a most laborious task. Dr. Hudson's great work was originally intended to contain in two volumes descriptions of the Rotifera of the whole

world, so far as at present known, but during its progress the British material accumulated to so great an extent that it became necessary to omit the greater number of the foreign species. These are briefly described in the present supplement together with all the new British species which have been discovered during the last three years—that is, since the issue of the main body of the work. Thus the future student of this group has the great advantage of having the results of preceding investigations incorporated in a single book of reference. While regarding with great satisfaction the successful completion of so great an undertaking, we cannot but share the regret expressed by Dr. Hudson that Mr. Gosse, whose name will probably be always more closely associated with these wonderful little creatures than with any other forms of aquatic life, did not live to see the completion of an enterprise that occupied so much of his thoughts. That his work did not slacken towards the close of his life is evident from the fact that no less than sixty of the species here described are new British forms discovered by himself. Four beautifully executed, double-page plates, from drawings by the author and his late colleague, contain representations of about 150 species, or almost all that are included in the supplement. The descriptions are frequently accompanied with interesting notes as to the habits and movements of the animals. Special interest attaches to two species of *Calladina* here included, on account of the strangeness of their habitat, which is upon the leaves of *Jungermanniæ*, growing on the trunks of trees, the needful supply of water being obtained from the raindrops which trickle down the furrows of the bark.

Reports on Elementary Schools. 1852–1882. By Matthew Arnold. London: Macmillan & Co. 1889.—During the thirty-five years that Mr. Matthew Arnold was an Inspector of Schools, successive Administrations never troubled to ask whether he was not being employed in work which might well have been committed to men of coarser fibre instead of his wide experience being utilised in administrative educational reform. If the author of *Empedocles on Etna* and *Thyrsis* brought little zeal to the examination of needlework and the great problem as to the best kind of desks, he brought conscientiousness into the round of duty and made his reports vehicles of wise suggestion and penetrating criticism. Some of his recommendations have borne fruit; much that he sought to improve remains unaltered, nor will there be much approach made to his ideal of "an aim to train generally all who are born men to all which is human," while the system of "cram" and of payment by results is rampant. That grave defect, initiated by the Revised Code of 1881, it is hoped the New Code of 1889 will tend to abolish. In the note with which Sir Francis Sandford, to whom our thanks are due for rescuing the more important of Mr. Arnold's reports from the oblivion of H.M. Stationery Office, prefaces this volume, a becoming tribute is paid to the lamented author's work, the results of which "are written in much of our past educational history, and in the present working of our schools." What words of wisdom, what incisive touch of defects in home as in school training, lie scattered through this book, the following extract from the report for 1852, the year after Mr. Arnold's appointment, will exemplify:—

I am convinced there is no class of children so indulged, so generally brought up (at home at least) without discipline—that is, without habits of respect, exact obedience, and self-control—as the children of the lower middle class in this country. The children of very poor parents receive a kind of rude discipline from circumstances, if not from their parents; children of the upper classes are generally brought up in habits of regular obedience, because these classes are sufficiently enlightened to know of what benefit such a training is to the children themselves; but children of the class I am alluding to receive no discipline from circumstances, for they are brought up amid comparative abundance; they receive none from their parents, who are only half-educated themselves, and can understand no kindness except complete indulgence; and, in consequence, nowhere have I seen such insubordination, such wilfulness, and such a total want of respect for their parents and teachers, as among these children.

In the same report, speaking of pupil teachers, he refers to "the utter disproportion between the great amount of positive information and the low degree of mental culture and intelligence which they exhibit." In conjunction with this notice should be given to a useful Report on Commercial Education, which was presented some two years ago to the Associated Chambers of Commerce. Although it urges reform in our present miserably abortive system chiefly on the ground that we should be driven out of the world's markets by our better-trained rivals abroad, the taking of this lower level at starting is necessary, since what is taught at school should be designed to best fit a youth for the battle of life. "We must all either work or steal," as Carlyle says. Exercises in rapid calculations, their application to business transactions, a general knowledge of books used in the counting-house, a familiarity with the atlas, a knowledge of French and German or Spanish, are not exclusive of studies which shall so elevate and humanise that the leisure which follows the day's work be not spent over the last sensational novel or in the degrading atmosphere of the music-hall. Certain it is—and "we speak that we do know"—that the majority of youths who offer themselves for business appointments, and on many of whom hundreds of pounds have been spent, are ill-equipped, knowing little, and careless about knowing much. They write badly; they cannot add up a column of figures correctly, and the answers which they give to the simplest questions in geography, and to such elementary questions as the size of the earth and the cause of day and night, equal in their painful drollery some of the famous examples in *English as She is Taught.*

E. Clodd.

Farm Live Stock of Great Britain. By Prof. Robert Wallace, F.L.S., &c., Prof. of Agriculture and Rural Economy in the University of Edinburgh. (Oliver & Boyd. 1889.) This is a handbook of the different breeds of cattle, sheep, pigs, and horses found in the British Isles, with useful directions for their management in health and disease. No one interested—and who is not?—in farm animals, and the history of their improvement under scientific treatment, will fail to acknowledge a debt of gratitude to Prof. Wallace for his volume, with its numerous very beautiful photographic illustrations, which one might at first mistake for steel engravings. Prof. Wallace has, by a new process of photographic reproduction, presented us with a series of truthful portraits of representative prize-winners in the leading classes of show animals. They are not all equally good from an artistic point of view, as the facilities for photographing animals at our public exhibitions are not what they might be, if the importance of keeping such a register were recognised by the judges. We are, however, provided in Prof. Wallace's volume with a gallery of the most interesting and instructive character, by which a comparison can be instituted between the points of the principal breeds. The author has aimed at condensation throughout—as was indeed needed in such an extensive subject—but we should have been glad if he could have spared us a little farther space for the historical part of his subject.

A list of the most important herds of each breed might also be added, with advantage, to the next edition.

Primer of Cursive Shorthand. (The Cambridge System.) By H. L. Callendar, M.A., Fellow of Trinity College, Cambridge. London: C. J. Clay & Sons, Ave Maria Lane. 1889. *Reading Practice. Facsimiles of Actual Writing.* By H. L. Callendar, M.A., Fellow of Trinity College, Cambridge. London: C. J. Clay & Sons, Ave Maria Lane. 1889.—Mr. Callendar has followed up the publication of his "Cursive Shorthand," noticed in Knowledge for March, by the issue of a sixpenny Primer, and two threepenny Reading-books of eight pages each. These will be of assistance to the student. The reading-books are to be multiplied as occasion demands. In these days of shorthand competition Mr. Callendar does well to give to those learning his system advantages offered by other authors; though his methodical treatment of the subject will probably save him from the labour of compiling, and his students from the drudgery of studying, a Cursive Dictionary. For reporting scientific language with ease and accuracy, the systems that depend in practice upon consonantal skeletons are wholly inadequate. Only a joined vowel system, such as Mr. Callendar's is, can have any pretensions to deal effectively with technical terms.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

MORE PROPERTIES OF NUMBERS.

To the Editor of Knowledge.

Sir,—I have just read, with considerable interest, Mr. T. B. Russell's letter on the above subject in the September number of Knowledge.

When the whole of the multiplication-table is dealt with on the lines which he suggests, and the result tabulated, the phenomena exhibited is very curious, and some of the peculiar properties of numbers still further demonstrated.

It will be remembered, by those who have read Mr. Russell's letter, that he introduces the subject by a reference to the well-known "property which is possessed by the integers of all multiples of 9, namely, that when they are added successively until only one figure remains, that figure will always be 9."

After applying the same process to three other numbers of the table—8, 5, and 6—Mr. Russell remarks that while none of them possess the same property as the number 9, "in each case some sort of order or progression was exhibited by the sums of the integers."

This "order or progression" is more marked when the process is applied to the whole table.

I reproduce his experiments with table 8 for reference:

8×1			$=$	8
$8 \times 2 = 16$	$6 + 1$		$=$	7
$8 \times 3 = 24$	$2 + 4$		$=$	6
$8 \times 4 = 32$	$3 + 2$		$=$	5
$8 \times 5 = 40$	$4 + 0$		$=$	4
$8 \times 6 = 48$	$4 + 8 = 12$	$2 + 1$	$=$	3
$8 \times 7 = 56$	$5 + 6 = 11$	$1 + 1$	$=$	2
$8 \times 8 = 64$	$6 + 4 = 10$	$1 + 0$	$=$	1
$8 \times 9 = 72$	$7 + 2$		$=$	9

and so on.

Beginning with the first number of the multiplication-table and applying the same process to the first eight consecutive numbers, and tabulating the result in each case, we get the variety of series placed in the *vertical* columns of the following table, under each number respectively.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	
1	2	3	4	5	6	7	8							
2	4	6	8	1	3	5	7			2.	3.	4.	5.	
3	6	9	3	6	9	3	6							
4	8	3	7	2	6	1	5	all nines.	same as table 1.					and so on.
5	1	6	2	7	3	8	4			„	„	„	„	
6	3	9	6	3	9	6	3							
7	5	3	1	8	6	4	2							
8	7	6	5	4	3	2	1							
9	9	9	9	9	9	9	9							

If the process be applied to the next eight consecutive numbers of the table after 9, or to the eight consecutive numbers which follow any multiple of 9, the result will be a repetition of the same series in the same order, *ad infinitum.*

It follows, therefore, from this, that if the process be applied to consecutively higher *multiples* of any numbers in the above order the result will also be the same, *ad infinitum.*

The above table, therefore, exhibits the whole series of numbers which would be obtained by an application of the process to the entire multiplication table.

Let us note a few of its phenomena.

(*a*) The sum of each series is a multiple of 9. The integers of the sum of each series when added each make 9.

(*b*) The series in the first vertical column is the same as that in the first horizontal column. That in the second vertical the same as that in the second horizontal, and so on to the end of the table.

(*c*) The series in the vertical columns 1, 2, 3 and 4, are the same, *but in the reverse order*, as the series in columns 8, 7, 6 and 5 respectively, viz,, 1 and 8, 2 and 7, 3 and 6, 4 and 5.

(*d*) The series in column 10 (when produced) is the same as in column 1, 11 the same as 2, 12 the same as 3, and so on.

From (*c*) and (*d*) we can deduce two simple rules.

From (*c*) we note that any two numbers whose sum is 9 (or any multiple of 9) will produce the same series but in the reverse order; *e.g.*, $9^2=81$, $22+59=81$. Therefore if the process be applied to 22 times, and 59 times any eight consecutive numbers; they will each produce the same series but in the reverse order.

From (*d*) we note that if any of the numbers at the head of the table (higher than 9) be divided by 9, the *remainder* will indicate the column in which the series may be found which such number will produce; *e.g.*, $12 \div 9 = 1$, and 3 remainder. Therefore 12 times will give the same series as 3 times. Again, taking a much higher number, $78424 \div 9 = 8713$, and 7 remainder, Therefore 78424 times any 8 consecutive numbers to which the process is applied will produce the same series as 7 times. Any number which divides by 9 without a remainder will, of course, give the same result as 9.

I suppose all the above are explicable on the same lines,

Yours obediently,

Wm. Staniforth.

Upperthorpe, Sheffield: Sept. 19th, 1889.

[I have to thank very numerous correspondents (26 in all) for letters on the above subject. Mr. Staniforth's letter, perhaps, puts the facts more concisely than any other. The fact that the sum of the digits of any multiple of 9 is itself a multiple of 9, may be made evident thus: With the decimal notation we use any number may be written as a series of powers of $(9+1)$ multiplied by digits; for example, 3591 may be thrown into the form—

$$3\,(9+1)^3+5\,(9+1)^2+9\,(9+1)+1$$

When these binomials are multiplied out, every term will contain a 9, except the last of each—so that if the sum of the last terms, that is the sum of the digits, happens to be a multiple of 9, the whole number is so, and *vice versa*. It is evident that the series of numbers corresponding to the sums of the digits of successive multiples of 8 decreases by steps of one at a time; because, if we add 8 to any number we usually decrease the number in the integer place by 2, and add 1 to the number in the tens place, which decreases the sum of the digits by 1. Multiples of 8 never have a 1 in the last place, but the passing from 1 to 9 and from 0 to 8 is really a step backwards of 2 if we consider the figures to be written in a circle, or in an endless recurring series. Similarly the series of numbers corresponding to the sums of the digits of successive multiples of 7 decreases by steps of 2 at a time, and so on till we get to multiples of 4, when the step backward is 5 at a time, which with groups of 9 bring you to the same numbers as stepping forwards 4 at a time, and stepping backwards 6 at a time gives the same numbers as stepping forwards 3 at a time. Mr. Staniforth's square shows that the well-known 9 rule is only a particular case of a more general law, when the steps of the series are 0 at a time, and as you begin with 9 you never get any further.—A. C. Ranyard.]

DO VIPERS PROTECT THEIR YOUNG IN TIME OF DANGER BY SWALLOWING THEM?

To the Editor of Knowledge.

Sir,—There still seems considerable doubt among several of your correspondents concerning the correct answer to the above query. Will you allow me to relate my experience? When I was a lad between thirteen and fourteen years of age I started with a party of ten or a dozen boys from Chichester for Goodwood on a butterfly-catching expedition. We arrived on the downs, and, after very fair success in chasing and capturing insects, were fain to rest our tired limbs on a log which lay just on the outskirts of a plantation of pine trees. Boys that we were, we could not sit still very long, so began to roll the log as we sat on it. Just from under my part of the log out came an adder, making, if I remember rightly, a slight hissing noise, and followed by some five or six little vipers, I should think, of about one and a-half to two inches in length. The mother, as we took it to be, opened her mouth, and the little ones glided instantly into it and disappeared, as also did the mother, into the thick grass of the adjoining scrub.—I am, yours truly,

H. Combes.

Haverstock Hill Board School, N.W.

THE FACE OF THE SKY FOR NOVEMBER.

By Herbert Sadler, F.R.A.S.

The increasing number of sunspots, though no very large ones have yet appeared, shows that the minimum is now fairly past. Conveniently observable minima of Algol take place on the 1st at 7h. 53m. p.m., on the 4th at 4h. 12m. p.m., on the 21st at 9h. 35m. p.m., and on the 24th at 6h. 24m. p.m. A minimum of λ Tauri occurs at 5h. 5m. p.m. on the evening of the 1st. In this star the change of light from normal brilliancy (3·4 magnitude) to minimum (4·2 magnitude) and back again takes a little more than 10 hours. Mercury is well situated for observation during the first three weeks of the month. On the 1st he rises at 4h. 58m. a.m., or just two hours before sunrise, having a southern declination of 6° 26′, and an apparent diameter of $6\frac{1}{2}''$. On the 19th he rises at 6h. 24m. a.m., or rather less than an hour before the sun, having a southern declination of $16° \frac{1}{2}''$, and an apparent diameter of 5″. On the morning of the 10th he will be about $1\frac{1}{4}°$ *s.p.* the 4th magnitude star κ Virginis. During the month he passes from Virgo through Libra into Scorpio. Venus is a morning star, but is rapidly losing her brilliancy. On the 1st she rises at 4h. 18m. a.m. with a southern declination of $3° \frac{3}{4}'$, and an apparent diameter of $11\frac{1}{4}''$; just $\frac{9}{10}$ths of the disc being illuminated. On the 30th she rises at 5h. 54m. a.m. with a southern declination of $16\frac{1}{4}°$, and an apparent diameter of $10\frac{1}{2}''$. On the morning of the 4th she will be about 8′ *s.p.* the $4\frac{1}{2}$ magnitude star θ Virginis. During the month she passes from Virgo into Libra. Mars is a morning star, but is not a very attractive object for amateurs, as his diameter at the end of the month only subtends $5\frac{1}{2}''$. On the 1st he rises at 2h. 36m. a.m., and on the 30th at 2h. 20m. a.m. He is in aphelion at 7h. a.m. on the 12th. On the morning of the 3rd he is about 50′ *s.p.* β Virginis. During the month he passes from Leo into Virgo. Jupiter must now be looked for very early in the evening near the SSW. horizon, if he is to be observed at all. On the 1st he sets at 7h. 30m. p.m., or three hours after sunset, with a southern declination of $23\frac{1}{2}°$, and an apparent diameter of 34″. On the 30th he sets at 6h. 3m. p.m., or two hours six minutes after sunset, with a southern declination of 23° 10′, and an apparent diameter of $32\frac{1}{2}''$. On the evening of the 13th he will be 11′ due north of the 6th magnitude star B.A.C. 6343. He is in Sagittarius throughout the month. The following three phenomena of the satellites occur between the times of the planet's being 8° above, and the sun's being 8° below, the horizon on the days named. On the 1st a transit egress of the shadow of the first satellite at 5h. 18m. p.m. On the 8th a transit ingress of the shadow of the first satellite at 5h. 25m. p.m., and on the 10th an eclipse (disappearance) of the third satellite at 5h. 10m. 47s. Saturn is a morning star, in Leo throughout the month. On the 1st he rises at 0h. 30m. a.m., having a northern declination of 11° 55′, and an apparent diameter of $15\frac{1}{2}''$. On the 30th he rises at 10h. 40m. p.m., having a northern declination of $11\frac{1}{2}°$, and an apparent diameter of $16\frac{1}{2}''$. Marth points out that on November 1st, at 8h. p.m., the satellite Japetus passes within 3″ of Titan, and shortly afterwards enters the shadow of the ring system, from which it emerges between 4h. and 5h. p.m. on November 2nd. Uranus is, for the purposes of the amateur, practically invisible. Neptune rises on the 1st at 5h. 36m. p.m., having a northern declination of $19\frac{1}{4}°$, and an apparent diameter of $2\frac{3}{4}''$, and shines as a dull 8th magnitude star. On the 30th he rises at 3h. 36m. p.m. He moves slowly to the west during November, and is in opposition to the sun on the 25th, when his distance from the earth is about 2,683 millions of miles. He is between ω (Omega) and 43 Tauri, gradually approaching the latter. November is a very favourable month for shooting stars. The most marked displays are the *Leonids* on November 13 and 14, the radiant point being in R.A. 10h. 0m. Decl. + 23°. The radiant point rises at about a quarter past ten p.m. The *Andromedes* occur on the 27th, the radiant point being in R.A. 1h. 40m. Decl. + 43°. The moon is full at 4h. 5m. p.m. on the 7th, enters her last quarter at 8h. 36m. p.m. on the 15th, is new at 1h. 11m. a.m. on the 23rd, and enters her first quarter at 5h. 29m. p.m. on the 29th. On the 3rd the $4\frac{1}{2}$ magnitude star 30 Piscium will disappear at 9h. 41m. p.m. at an angle of 132° from the vertex, and reappear at 10h. 55m. p.m. at an angle of 317° from the vertex, and

the same evening the $1\frac{1}{2}$ magnitude star 38 Piscium will disappear at 11h. 50m. P.M. at an angle of 110° from the vertex, and reappear at 0h. 44m. A.M. on the 4th at an angle of 7° from the vertex. The same morning there will be a near approach of the 6th magnitude star B.A.C. 17 at 3h. 2m. A.M. at an angle of 63° from the vertex. On the 7th at 6h. 45m. P.M. the $6\frac{1}{2}$ magnitude star B.A.C. 987 will disappear at an angle of 57° from the vertex, and reappear at 7h. 44m. P.M. at an angle of 275° from the vertex. On the 8th there will be a near approach of the 6th magnitude star B.A.C. 1272 at 11h. 23m. P.M. at an angle of 2° from the vertex. On the 11th the $6\frac{1}{2}$ magnitude star 141 Tauri will disappear at 6h. 7m. A.M. at an angle of 103° from the vertex, and reappear at 7h. 8m. A.M. (four minutes before sunrise) at an angle of 340° from the vertex. On the 18th the 4th magnitude star ν Virginis will disappear at 2h. 4m. A.M. at an angle of 14° from the vertex, and reappear at 3h. 3m. A.M. at an angle of 225° from the vertex. On the 28th the $6\frac{1}{2}$ magnitude star 29 Aquarii will disappear at 3h. 36m. P.M. at an angle of 177° from the vertex, and reappear at 9h. 29m. P.M. at an angle of 293° from the vertex. This is a pretty pair of 7 and $7\frac{1}{4}$ magnitude stars 3·7″ apart. On the 29th the 4th magnitude star τ^2 Aquarii will disappear at 3h. 48m. P.M. (six minutes before sunset) at an angle of 83° from the vertex, and reappear at 5h. 1m. P.M. at an angle of 292° from the vertex. This is an orange-coloured star, with a blue 9th magnitude companion at 132″ distance.

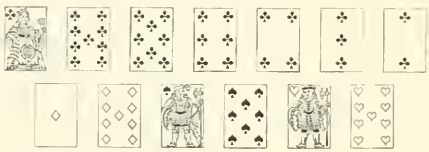
Whist Column.

By W. Montagu Gattie.

THE DISCARD FROM A WEAK SUIT.

The following hand, which is contributed by Mr. H. F. Lowe, affords a simple illustration of the importance of the discard as a means of information. The player whose hand is exposed leads one of his long trumps in order to ascertain from his partner's discard which of two is his strong suit.

Hand No. 6.

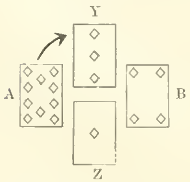


Z's Hand.

Score—Love All. Z turns up the four of clubs.

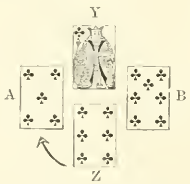
Note.—A and B are partners against Y and Z. A has the first lead; Z is the dealer. The card of the leader to each trick is indicated by an arrow.

Trick 1.



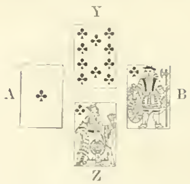
Tricks—AB, 0; YZ, 1.

Trick 2.



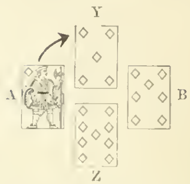
Tricks—AB, 0; YZ, 2

Trick 3.



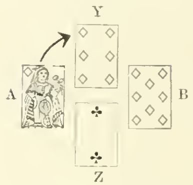
Tricks—AB, 1; YZ, 2.

Trick 4.



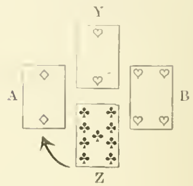
Tricks—AB, 2; YZ, 2.

Trick 5.



Tricks—AB, 2; YZ, 3.

Trick 6.

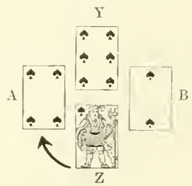


Tricks—AB, 2; YZ. 4.

Notes.—*Trick* 5.—Scientifically speaking, it would be more accurate to trump with the nine, and then lead the two, thus showing conclusively that he has the three intermediate cards. It is true that Y should know this from Trick 2, for Z must have two trumps higher than the six (*i.e.* the eight and nine), and, A and B having played five and seven respectively, he must also hold the small ones; but there is never any harm in telling one's partner a thing twice over.

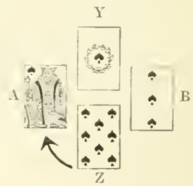
Trick 6.—This constitutes the point of the hand. Z has no means of knowing whether his partner's strength lies in spades or hearts. In order to win the game it is necessary to make all the remaining tricks, so that everything depends on Z's selecting the right suit. He therefore leads a trump in order that his partner's discard may guide him.

Trick 7.



Tricks—AB, 2; YZ, 5.

Trick 8.



Tricks—AB, 2; YZ, 6.

Tricks 9 *to* 13.—Y makes two more spades, on which Z discards his hearts, Z makes his three remaining trumps, and

YZ score Five By Cards.

A's Hand.	B's Hand.
C.—Ace, 5.	C.—Kn, 7.
D.—Kg, Qn, Kn, 10, 2.	D.—8, 7, 4.
S.—Kg, 4.	S.—7, 5, 3, 2.
H.—Kg, 8, 6, 3.	H.—Ace, Qn, 10, 4.
Y's Hand.	**Z's Hand.**
C.—Kg, 10.	C.—Qn, 9, 8, 6, 4, 3, 2.
D.—6, 5, 3.	D.—Ace, 9.
S.—Ace, Qn, 10, 9, 6.	S.—Kn, 8.
H.—7, 5, 2.	H.—Kn, 9.

Remarks.—*Tricks* 2 *and* 3.—After these tricks, as already pointed out, Y can place the remaining trumps in Z's hand.

It is worth noticing that, if Z had led his lowest, or even his penultimate, trump at Trick 2, Y could not have known where the eight and nine were until three tricks later.

Trick 4.—A's lead is in accordance with the American code, which provides that, when ten, led from king, queen, knave, ten, draws the ace, the original leader should continue with knave if he opened from a five-suit, and with queen if he opened from a four-suit. But, in the present instance, as A is playing a losing game, we should have preferred to continue with the king, so as to keep Z in the dark as long as possible as to the position of the queen. As the cards lie, it does not matter which of the three is led first.

Trick 5.—It may be urged that, since there is nothing to show that Y has not another trump, A, by going on with the diamonds, runs the risk of enabling him to make it separately. But this would, under the circumstances, be an advantage, since Y would then have to lead up to A in either spades or hearts.

Trick 7.—A plays correctly, we think, in passing the knave, for Z may not have another spade, and in that case, if the knave wins, will have sooner or later to lead a heart. This chance seems preferable to the chance of B's holding the ten twice guarded. Of course, if B holds either ace or queen of spades, A's play is immaterial.

Elementary Explanation of the Play.

Trick 1.—The ten is the proper lead from a suit headed by king, queen, knave, ten, or by king, knave, ten. B infers from this trick that Z has not the queen, but neither B nor Z can at present tell whether it is with A or Y. On the other hand, Y can place the queen with A, for if either of the others had held it he would have played it.

Tricks 2 *and* 3.—Z, of course, opens trumps; and Y, equally of course, returns them. The student should observe that Z, having led a low card, must have at least three better; and, therefore, after he has played the queen and the other high cards have fallen, he must hold the eight and nine, since these are the only two unplayed trumps higher than the six (his original lead). A and B, by playing the five and seven respectively, show each other that they have not the two or three (the four was the turn-up card), so that they know after Trick 3 that all the trumps are against them. But they cannot tell from Y's lead of the ten whether he has one of the small ones or not, for he would return the higher of two remaining cards.

It now appears that honours are "easy," and, therefore, the score being Love-all, YZ must make eleven out of the thirteen tricks in order to win the game.

Trick 4.—Clearly A can do no better than continue his winning diamonds.

Trick 5.—As a matter of fact, A would have saved the game at this point if he had led a heart; but it was, of course, quite impossible for him to know this, or to foresee that with king guarded in each of the other suits he would be unable to make another trick.

Trick 6.—Z has now drawn all the adverse trumps, and is in possession of the lead. He knows that diamonds are against him, but has no clue as to his partner's strength in the other two suits. His lead of a trump amounts to asking his partner the question, "What would you like me to lead?" Y replies by throwing away a heart, which means to say, "My strong suit, which I want you to help me to establish, is spades." This is confirmed by B, who, in accordance with the principle explained in our last article (see Knowledge, vol. xii., p. 254) discards from his best-protected (*i.e.* strongest) suit. It is practically certain, therefore, that whatever strength Y has is in spades.

Trick 7.—Z accordingly leads his best spade, so as to assist his partner as much as possible. Y finesses against the king, because this is the only possible way in which the game can be won.

Chess Column.

By I. Gunsberg (Mephisto).

[Contributions of general interest to chess-players are invited. Mr. Gunsberg will be pleased to give his opinion on any matter submitted for his decision.]

The following interesting game was played in the Handicap Tournament at Simpson's Divan last month:—

White. F. J. Lee.	Black. O. C. Muller.	White. F. J. Lee.	Black. O. C. Muller.
1. P to Q4	P to Q4	9. B × P	P to QKt4
2. P to QB4	P to K3	10. B to Q3	P to B5
3. Kt to QB3	Kt to KB3	11. B to B2	B to Kt2 (*c*)
4. B to B4 (*a*)	B to Kt5	12. R to Bsq	QKt to Q2
5. P to K3	Castles	13. Kt to Kt3 (*d*)	Q to Kt3 (*e*)
6. B to Q3	P to QB4	14. B to Ktsq	Kt to QB (*f*)
7. Kt to K2	P to QR3	15. Kt × Kt	P × Kt
8. Castles (*b*)	P × BP		

Black.

White.

16. Q to R5 (*g*)	P to Kt3	28. Q to Kt3	Q to K2
17. Q to R6 (*h*)	KR to Ksq	29. Kt to B4	KR to Q3
18. Q to R4	QR to Qsq	30. Kt to Kt2	K to Rsq
19. P to QR3 (*i*)	B to K2	31. Q to Q5 (ch) (*k*)	Q × Q
20. Q to R3	B to QBsq (*j*)	32. P × Q	R to K3
21. Kt to K2	Kt to B3	33. KR to Qsq	B to K2
22. Q to Kt3	Kt to R4	34. P to B4	P to Kt4 !
23. Q to B3	B to B3	35. B to B5 (*l*)	R to QB3
24. P to KKt4	Kt × B	36. B × B	R (B3) × B
25. Kt × Kt	Q to Q3	37. R to B2	P to QR4
26. P to R3	B to Kt4	38. R (B2) to Q2	
27. Kt to K2	R to K3		

Black.

White.

White. F. J. Lee	Black. O. C. Muller.	White. F. J. Lee.	Black. O. C. Muller
	P to Kt5 (*m*)	43. Kt to Ksq (*n*)	P to B7
39. RP × P	RP × P	44. Kt × P	R × Kt
40. R × P	R × R	45. R to Q7	B to B4
41. R × R	P to B6 !	46. P × P	B × P (ch)
42. P × P	P × P	47. K to Bsq	K to Ktsq

And Black won.

NOTES.

(*a*) A move of doubtful value. If White wants to advance on the Queen's side he should leave the Bishop on Bsq; if, on the other hand, he wants to attack on the King's side, then the B on its own square would also be useful, or he might play B to Kt5

(*b*) White ought to have played P × BP, so as to provide against the advance of Black's Pawns on the Queen's side, prepared by Black's last move.

(*c*) Black has gained very important time, and has brought his Queen's Bishop which otherwise would have been locked in, into very useful activity.

(*d*) White is, apparently, trying to prepare for an advance of his King's Pawn, but when that is done the Queen's Pawn becomes weak.

(*e*) The proper move, especially if he anticipates an advance in the centre; it makes the Queen more useful, and admits of QR to Qsq, if requisite.

(*f*) Black wants to force an exchange to block the centre, being content to rely on the superiority of the position of his Pawns on the Queen's side, for the End-game. We should have adopted a different course.

(*g*) The only effect of this move is to strengthen Black's position, for by playing P to Kt 3 he cuts off the possibility of an advance of the White Knight, and also prepares to place his King's Bishop into a more useful position by KR to Ksq, B to Bsq and B to Kt2, if necessary. White had a much better move in 16. Kt to B5, threatening 17. Kt × PK × Kt 18. Q to Kt4 recovering the piece. If in reply to 16. Kt to B5 Black plays P to Kt3, he may either fix his Knight on R6, or perhaps, better still, play 17. P to QR3.

(*h*) White has evidently lost hold of his game from an early stage; his moves are aimless.

(*i*) When there are two Pawns to 3 on the Queen's side, the Pawns are weaker if one is advanced to QR3.

(*j*) How that poor Queen has to suffer for the one indiscreet sixteenth move. She is now sorely pressed, and has none too many places to hide her guilty head out of sight of the vengeful Bishop's having evil designs of capturing her. Black is certainly handling his forces in an admirable manner.

(*k*) It was a mistake to exchange Queens here, because Black's position improves thereby on the Queen's side. He will soon force a passed Pawn.

(*l*) This Bishop has been absolutely useless to White all the game through.

(*m*) An ingenious move. Black is now reaping the advantage of his superiority of position on the Queen's side, which he had been consistently playing for from the very beginning of the game.

(*n*) He cannot stop the Pawn otherwise, for if 43. R to Qsq, P to B7, 44. R to Bsq, B to R6 wins.

TEACHING CHESS.

A Chess instructor now-a-days has rather a difficult task to perform. If he is of the modern school, he is brimful of new theories of the Openings (so he thinks), and he is overburdened—hackneyed with stereotyped notions of chessy wisdom, which he calls general principles. He has observed either in his own experience, or that of other players, that defence is easier than attack, that it pays wonderfully well to play a featureless and restrained game, and that it is unprofitable to venture on Gambits and the like. New discoveries in the Openings prove (to him) most of the formerly practised lines of play to be unsafe. For, be it noted, your modern analyst only makes negative discoveries—he never originates anything. In fact, if he be a conscientious teacher, he should say to his pupils: My defensive philosophy consists in never risking anything, and principally in trying not to lose the game rather than trying to win it, and if he were to speak his mind freely, he would tell you that there are really but two reliable Openings, the Ruy Lopez (that "sheet anchor of dull mediocrity"), and the Irregular game. He knows of many eminent players who have won (small tournaments) high honours (never the highest), and who never play anything else, but either or both of these Openings. He admires the soundness of these masters (whom I may be pardoned in comparing to "penny automatics"—the machine on being set in motion plays 1. Kt to KB3, or 1. P to Q4 with inanimate uniformity). Well now, if a teacher modernised to that extent essays to teach a tyro how to play the noble game, he is placed in a position of extreme difficulty. If he is a man of wisdom he will endeavour to fascinate and cultivate Tyro's imagination—for the tyro wants to play *chess*—leaving the practice of his defensive philosophy, his surfeit of modern theories and principles to those disciples of the new cult, who neither love and practise chess as amateurs, nor care for, nor honour it, as a profession, but who have made a trade of playing in tournaments, and to whom therefore, not losing a half a point, by not incurring even a particle of risk, is of more importance than playing *chess*. But if he be foolish enough to say to the beginner that there is no salvation to be found except in the Ruy Lopez or Irregular, and that the acme of wisdom is to play for position only—*i.e.* apply the principles of Draughts to Chess, and that the grand result of all correct play is a drawn game, then he will probably do nothing else but excite a distaste for Chess in the minds of his pupils, most of whom cannot understand him, and would not assimilate his teachings. Moreover, he would be advocating unreliable, if not false doctrines; for his teaching, his new style of play, is only the reflex action of an imagination naturally deficient, or weakened in nature's course, and his theories only hold good and produce their effect against inferior attack; they would fail to make any impression on play conducted on the same basis, and would be dispelled like chaff before the wind when opposed to imaginative play of the highest order.

"Whitehaven" asks our opinion of "the feasibility or otherwise of a transposition from the Vienna Opening to the Centre Opening (Paulsen's attack). Thus—

1. P to K4	1. P to K4
2. Kt to QB3	2. Kt to KB3
3. P to Q4	3. P × P
4. Q × P	4. Kt to B3
5. Q to K3	

It appears to me that Black may with advantage refuse to play 3. P × P, and instead pin the Knight with 3. B to Kt5. [Quite right, I. G.] If there be no other way of avoiding the transposition, it would appear to strengthen the claims of the Centre Opening."

Not at all, for apart from Black's third move his position is the same as in the normal game, arrived at as follows:—

1. P to K4	1. P to K4
2. P to Q4	2. P × P
3. Q × P	3. QKt to B3
4. Q to K3	4. Kt to B3
5. QKt to B3	

We have now the same position as before. Black may play B to Kt5, and he will obtain a good development. The usual course, by proper play in this Opening, is not to play P to Q3, but, after B to Kt5, Black should endeavour to Castle, play his Rook to Ksq, and play P to Q4, when he will have a good game, somewhat in the following order:—

5.	5. B to Kt5
6. B to Q2	6. Castles
7. Castles	7. R to Ksq
8. P to B3	8. P to Q4, &c.

Contents of No. 48.

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KNOWLEDGE

AN ILLUSTRATED

MAGAZINE OF SCIENCE

SIMPLY WORDED—EXACTLY DESCRIBED

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CONTENTS.

ROCK-PINNACLES.

By Prof. G. S. Boulger, F.L.S., F.G.S., &c.

Few considerations are more conducive to a due sense of human littleness and of the grandeur of Nature than a study of the manifold ways in which physical causes will sometimes bring about the same result. Towering over an English heath or moor, or overhanging the sides of a romantic river-worn ravine, rising among Swiss pine-clad slopes, withstanding the fury of Atlantic waves off the coasts of Orkney or Cornwall, or standing up out of the arid plains of Colorado, we see pinnacles of stone, forming an integral part of the neighbouring rocks, but hewn in divers ways by Nature's hands. Often grotesque in outline, suggesting a squatting toad, a huge heathen idol, a Christian pulpit, or the human form, they present to our imagination—

> Shapes,
> The sport of nature, aided by blind chance,
> Rudely to mock the toiling works of man.

This "blind chance" is, however, as in so many other supposed cases of its operation, susceptible of scientific examination. Varied as have been the forces at work, and still more varied as their combined results may appear, they will yet reveal their secret to the geologist, obedient to the charm which he received from his master-magician Lyell: "causes now in action are the same as those in operation in the past." We propose to describe some typical examples of these rock-pinnacles, and to attempt the elucidation of their origin. First, however, we must explain that by a "rock-pinnacle" we understand a mass of rock, more or less tower-like, detached above, but united below to other rock of the same nature. By this definition the consideration of wholly detached, or stranded, masses is for the present put aside.

Where our coast-line is made up of soft or loose material, as is mainly the case from Tees to Thames, we have wide-sweeping bays, such as Bridlington, low cliffs such as those of Suffolk or Sheppey and a retreating and changing outline; but few projecting pinnacles or rock-stacks. The waves sweep everything away before them. Where, however, we get even moderately hard rocks at the sea-margin we at once have very different shores. Here the coast rises in abrupt cliffs descending into deep water, or a pebbly shingle extends at their feet: there foam-tossing breakers indicate the submerged skerry; and there again rises perchance a solitary pillar marking the former line of shore, or with a neighbouring natural arch indicating its origin.

At the western extremity of the Isle of Wight are the well-known Needles and the former continuity of the chalk downs of the Island with those of Dorsetshire—ere the sea broke its way into the valley of the Frome, converting it into what we now know as the Solent—is marked by the similar pinnacles, Old Harry and his Wife, the Spiral Rock and the Barns, off Bollard Head on the opposite coast. The chalk of which the Needles are composed has been tilted, so that its once horizontal beds are now nearly vertical, and of the "joints" or divisional planes by which it is traversed in addition to its bedding-planes—due, also, as many geologists believe, to the strain to which the rock has been subjected—the dominant ones, the "master-joints," though at right angles to the bedding, rise also almost vertically from the water. These two sets of divisional planes have determined the direction of Nature's quarrying, as surely as they determine that of man's work in every freestone pit or in every coal-mine. But what has been the quarrying agency? At first we might be inclined unhesitatingly to attribute it to the sea.

The precipitous Old Red Sandstone cliffs of Caithness and the Orkney and Shetland Islands, graphically described by Dr. Archibald Geikie, furnish apparently still more striking instances of marine action. Here in the Race of Pentland we have the full fury of the Atlantic. "On the calmest day some motion of air always keeps playing about the giddy crest of the precipices, and a surge with creaming lines of white foam meets at their base. But when a westerly gale sets in, the scene is said to be wholly indescribable. The cliffs are then enveloped in driving spray torn from the solid sheets of water which rush up the walls of rock for a hundred feet or more." The mere weight of water in these waves is amply sufficient to detach fragments of rock, amounting as it often does to three tons on the square foot; but the action is enormously intensified by the existence of crevices or fissures in the rock. Every such cleft or chink becomes, as it were, a hydraulic press, in which the in-rushing wave acts on every side with a force equal to that with which it strikes the face of the rock. Perhaps even more effective, however, than this direct pressure of the water is the alternate compression and expansion of air which it produces. It was such suction of a retiring wave that, during a storm in 1840, burst a door of the Eddystone Lighthouse outwards; and it is, no doubt, such suction that starts large blocks of well-built masonry from their places, and will rapidly enlarge a cavity so commenced. It is this action probably that mainly explains the quarrying of blocks over 13 tons in weight out of the solid rock at 70 feet above sea-level on the Bound Skerry, in the Shetlands, and the hollowing out of long tunnels or "blow-holes," even in granite coast-lines, as in the Bullers, or boilers, of Buchan. Dr. Geikie and other competent judges tell us, however, that the

fusillade of shingle hurled repeatedly against the cliffs is probably yet more destructive than either the weight of water or the compression of air.

Surely, then, when we find cliffs actually overhanging, as do those of the Brough of Birsa, in Orkney, or the Needles themselves, it is a sign of the undermining action of the ocean. But no; probably in every such case it will be found on examination that the rock forming the cliff has joints or other divisional planes inclined at a high angle inland. Joints or other divisonal planes, pre-existent in the rock, and only revealed by the denuding agent, determine, in fact, much of the outline of many very varied kinds of rock-pinnacles. Thus, in spite of such waves as those in the Pentland Firth above-mentioned, the Old Man of Hoy towers above the adjacent cliff from which it has been separated, a column of yellow and red sandstone more than 600 feet high, and almost four-square in its sharpness of outline. It consists, as described by Dr. Geikie, of almost horizontal beds of Upper Old Red Sandstone, resting on a pedestal composed of volcanic rock above and of inclined Caithness flags below.

So also the limestone stacks off the south coast of Pembrokeshire withstand the force of the Atlantic, though the lines of bedding and jointing with which they are marked tell a plain story of their former connection with the shore, a story confirmed by natural arches such as that known as "London Bridge," which are simply intermediary stages between the buttress and the pinnacle.

Overhanging cliffs, however, are rare; perpendicular ones, far from common. In the majority of cases we find they recede upwards: their upper portion wastes more rapidly than their base: subaërial action is, in fact, more potent in its more silent operation than all the combined terrific forces of the ocean. The pulverising action of the sun evaporating absorbed water, the wind, which sometimes tears large stones off the face of a cliff, and, above all, rain and frost are the agencies at work. Here, again, joints are of the utmost importance. It is down the joints that the rain mainly percolates; and it is thus along the joints that the winter's frosts flake off layer after layer from our cliffs, irrespective of the mineral composition of the rock.

Subaërial action being thus more powerful than marine, we might expect to find rock-pinnacles resulting from its agency elsewhere than along our sea-coasts; and so, indeed, we do. In many of the beautiful dales of Derbyshire, where rivers have excavated for themselves deep channels in the Mountain Limestone, huge buttresses of this rock project from the sides of the ravines, and some of these buttresses sometimes stand out detached from the side wall of rock as solitary pinnacles. Here the bedding is approximately horizontal, but rain-waters containing carbonic acid and frost have acted first along one set of joints, thus producing the buttresses, and then along the other set (there are commonly two) at right angles, so converting a buttress into a detached pinnacle. A precisely similar origin explains the Devil's Chimney, the detached pinnacle of oolitic limestone that stands in front of the Cotteswold escarpment near Cheltenham; or the Pulpit Rock of chalk at Bonchurch; though these latter have perhaps to some extent been undermined and have slipped forward in consequence.

Where the Elbe cuts its way through the Erzgebirge into Saxony we have, in the Saxon Switzerland, somewhat similar results in sandstone. Innumerable pinnacles rise above the forests, showing distinctly their horizontal bedding, but cut out into blocks by their joints as if built up of gigantic masonry.

Granite "weathers," as the geologist terms this decaying process, in a similar manner. Though not stratified, it is frequently traversed by joints in horizontal as well as in vertical directions, along which the disintegration acts. Hard and indestructible as it appears, a very slight study of granitic districts shows us that it is far from being as independent of the weather as it seems. Whilst microscopic examination exhibits incipient alteration of the felspar of much granite near the surface into china-clay or kaolin, one can go into many a pit on Dartmoor and find what appear to be walls of granite rotted into a gravelly consistency, quartz, mica, and felspar embedded in soft clay resulting from the decay of the latter. Such decay is generally explained by the action of carbonic acid in rain-water. This converts, it is said, the silicate of potash into a soluble carbonate and leaves behind the silicate of aluminium in a hydrated condition—in fact, as clay. There are, however, difficulties in the way of so simple an explanation, and M. Daubrée has maintained that some fluoride, probably hydro-fluoric acid (which might well be supplied by the tourmaline, fluor, or lepidolite that are not uncommon as accessory minerals in granite areas) has been the chief agent in attacking the felspar.

Be the agency what it may, granite weathers on the summits of hills into remarkable piles of stones, the well-known "tors" of Dartmoor and of Cornwall, that rise from the rounded hill-tops like irregular fortifications or "Druidic" monuments. Hey Tor, Rippon Tor, and Helmen Tor are familiar examples of such stone-heaps; whilst the Cheesewring, north of Liskeard (a granite pile about fifteen feet in height), is further interesting from having been considerably undercut, being thus far wider across above than at its base. This decay along horizontal joints, sometimes accompanied perhaps by the action of blown sand, has so undermined some of these rock-masses that they can be rocked with ease upon their natural pivots. This is the case with several of the stones on Helmen Tor and with other granite masses in Devon and Cornwall, to which the generic name of Logans is applied. The best known of these is that near Castle Treryn, St. Leven, a mass weighing about 65 tons and over 30 feet in circumference. It rocks only in one direction, and loose gravel scattered over the pivot indicates the wear and tear still in progress.

The mention of this gravel brings us to the consideration of one agency very important even when acting alone, viz. wind-blown sand. In our climate it is difficult to eliminate rain and frost; but there are cases in which we may perhaps safely put down the greater part of the action to sand. Naturally these are among sandstone rocks. Near Pateley Bridge, Harrogate, are the Brimham Rocks. They are composed of Millstone Grit, the various layers of which differ considerably in compactness. The harder layers project as ledges; but those near the top of the detached pinnacles project far beyond the base, around which there is a plentiful supply of loose grit. One of these rocks has been cut by Nature into the semblance of some huge misshapen idol, and another is appropriately named the Pulpit Rock. More than one of them can be rocked. To realise the cutting effect of the blown sand, it is only necessary to hold one's face near the base of one of these exposed monoliths during a high wind.

Quartz sand, propelled by a steam blast at a pressure of 300 lbs. per square inch, will, in 25 minutes, bore a hole $1\frac{1}{2}$ inches in diameter and $1\frac{1}{2}$ inches deep in a solid block of corundum or sapphire, though this substance is 9 in von Mohs' scale of hardness, whilst the quartz is but 7; and though wind in a strong gale, travelling 70 miles per hour, exerts a pressure of only 16 lbs. per square foot,

yet the potency of sand under its influence upon sandstone cannot be gainsaid.*

The softer sandstones of the Hastings series in the south-east of England lend themselves readily to this process of weathering, as is well seen in the neighbourhood of Tunbridge Wells, at West Hoathly, and elsewhere in Sussex, and has been well illustrated in Mr. Topley's *Geology of the Weald*. On Rusthall Common, Tunbridge Wells, stands the Toad-rock, one of the most striking of such pinnacles. Situated in a hollow on the upland

The Toad Rock, Rusthall Common.

heath, surrounded by low cliff-like exposures of the same sandstone, this rock-mass shows very plainly the effects of the greater impregnation of some of its layers with iron-oxide in resisting the weather, and the action of the sand. Its base is ankle-deep in white sand; and as surely as we attribute the pot-hole, hollowed in the hard rock beside the bed of the mountain torrent, to the gyrations of the pebbles that now lie within it in the eddies of the stream, so surely do we assign to this sand, whirled round the pedestal of the toad-like mass, the grooves cut all round this pedestal as if turned in a lathe. Harrison's Rocks, near by, are but a less complete exemplification of the same process. At West Hoathly it is in the same series of sandstones—the upper beds of the Lower Tunbridge Wells sand, a sub-division of the Hastings series—that the rock-pinnacles, now in the private grounds of Rockhurst, occur. "Great-upon-Little," the most famous

Harrison's Rocks, near Tunbridge Wells.

mass, is estimated to weigh between 400 and 500 tons, and is so poised upon its undercut pedestal as to be slightly movable. Though there has here been some slipping, the isolation of the great blocks can be seen to be primarily due to weathering along joints. It is interesting to notice here, in the shady hollows, the Filmy Fern (*Hymenophyllum tunbridgense*) which once graced the sister pinnacles of Kent.

It is probably to entirely similar causes that we may attribute the often erroneously described Agglestone of Studland Heath, Dorsetshire. Tradition tells us that this mass of iron-shot sand, estimated to weigh 400 tons, was dropped by the Prince of Darkness himself, chief of all "aggles," hags, witches or warlocks, who had intended it for the destruction of Wimborne Minster or Salisbury Cathedral. "Guide" books speak of it as "druidical," and geologists, who can never have examined it, as a transported "Sarsen-stone." A slight examination of the steep little conical hillock, resembling a tumulus, on which it is perched, reveals the fact that it is part and parcel of this said mound, and is, in fact, but an extra hard portion of those Bagshot sands that form the whole heath and crop out so picturesquely in the Painted Rocks of Studland Bay. The resistance of a strongly impregnated iron-sand to the weather is the secret of its existence.

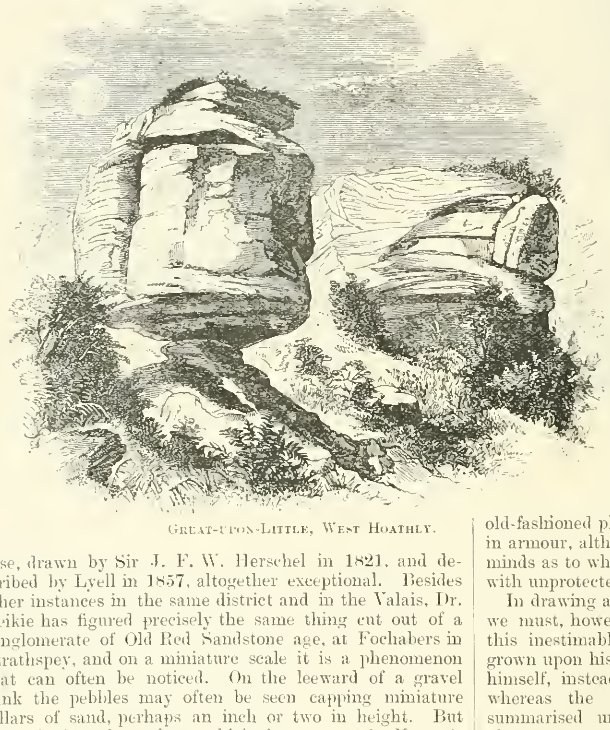
Did we go farther afield, to the arid plateaux of Colorado, we might find written yet more legibly, because not so obliterated by rain or frost, the tale of Nature's sand-blast. Here level plains, thousands of square miles in extent, intersected by cañons carved perpendicularly thousands of feet down through horizontal limestones, sandstones and shales, have been lowered by the removal of strata thousands of feet in thickness. The proof of this lies in the many-coloured cliffs whose projecting sand-polished ledges were the home of the ancient cliff-dwellers.

* The cutting power of sand, like the force of a blow, varies with the square of the velocity of the missile—according to experiments described at the Meteorological Society's meeting in May last by Mr. W. H. Dines. It was found that a pressure gauge, made to whirl round at the end of a long arm by steam power, registered a pressure of 1 lb. per square foot with a velocity of a little more than 17 miles per hour. Consequently, a wind of 69 miles per hour (which would be a very exceptionally high wind for England) would give a pressure of about 16 lbs. per square foot, and a pressure of 300 lbs. per square inch would be given by a wind blowing with a velocity of 850 miles per hour. I am not disposed to attribute such cutting power to sand blown by winds as Professor Boulger seems inclined to. The sharpness of many Egyptian carvings and inscriptions which have been bombarded by desert sand for 3,000 years is very remarkable. They are, however, generally cut in very hard rock, and have not been exposed to frost and rain. —A. C. Ranyard.

Note on Mr. Ranyard's Note.—It is perhaps the undercutting that most clearly exemplifies blown-sand action, this not being, I think, explicable by mere rain and frost. The examples I have quoted are in sandstone or limestone, not in granite or harder rocks.—G. S. Boulger.

and in the flat-topped, perpendicular-sided "buttes," or outliers, that still rise above the wind-swept plains.

We have not even yet exhausted the causes that may give rise to rock-pinnacles. The Finsterbach, near Botzen in the Tyrol, flows down a steep-sided ravine about 200 yards across and 400 to 500 feet deep, excavated in a glacial moraine of red mud, containing many large stones. Rain beating down upon the banks of this ravine, which slope at an angle of more than 30°, has washed away much of the mud; but each stone protects the earth beneath it, and, in so doing, becomes the capstone of a mud-column. Hundreds of these columns, or "earth-pillars," line the flanks of the ravine, of every height and age. Nor is this case, drawn by Sir J. F. W. Herschel in 1821, and described by Lyell in 1857, altogether exceptional. Besides other instances in the same district and in the Valais, Dr. Geikie has figured precisely the same thing cut out of a conglomerate of Old Red Sandstone age, at Fochabers in Strathspey, and on a miniature scale it is a phenomenon that can often be noticed. On the leeward of a gravel bank the pebbles may often be seen capping miniature pillars of sand, perhaps an inch or two in height. But what signifies the scale on which she operates? Nature's laws are as well exemplified in small things as in great; and here in the action of rain alone, cutting vertically, we have yet one more of her manifold processes for the manufacture of rock-pinnacles.



Great-upon-Little, West Hoathly.

MAIL-CLAD ANIMALS.

By R. Lydekker, B.A. Cantab.

Among civilized nations throughout the world the practice of protecting their fighting-men by coats of mail, which prevailed so extensively during the middle ages, has been entirely abandoned; the cuirass of the English Household Cavalry and of the French Cuirassiers being a survival, or, as Naturalists would say, a rudiment, of the complete coat of mail, which is retained more on account of the smartness which it adds to the equipment than for any practical use as a protection. The use of armour as a protection has, indeed, been transferred from men's bodies to the sides of ships of battle; and even there it appears problematical whether the ever-increasing weight of the armour which is necessary to keep pace with the development in the size and speed of the missiles employed against it will not eventually, as was the case with human armour, become so burdensome as to lead to its abandonment.

In the case of the coats of mail of the mediæval warriors a gradual process of evolution had, indeed, brought them to a marvellous pitch of perfection at the time when they were once for all abandoned; and the beauty of the suits of chain- and plate-armour, both as works of art and as admirable adaptations for their particular purpose, must at once strike all who visit a gallery of ancient armour.

If now we direct our attention to the animal, as distinct from the human, world, and confine our survey to that portion of it which includes the backboned, or, as Naturalists term them, the vertebrate animals, we shall find in the early periods of the earth's history a great tendency in many groups to the development of a coat of mail, fully as beautiful, and frequently much more efficient than that of the knights of old. We shall find, moreover, that on the whole vertebrate animals have, so to speak, come to the conclusion that a coat of mail is not altogether an advantage, more especially among the higher forms, in the struggle for existence; and that a better protection is to be found in the swiftness of limbs for flight, or in the length of teeth and talons for attack. Still, however, there are certain groups of animals which have preserved the old-fashioned plan of living and fighting the battle of life in armour, although even some of these seem to be in two minds as to whether, after all, the plan of facing the world with unprotected bodies is not really the best.

In drawing a parallel between human and animal armour we must, however, remember always that the animal has this inestimable advantage over man, that his armour is grown upon his own body, and is in fact part and parcel of himself, instead of having to be put on and off. Again, whereas the chief types of human armour may be summarised under the three forms of chain- scale- and plate-armour, we find a much greater variety prevailing in the coats of mail of animals. And here we would impress upon the reader who has followed us thus far, how much knowledge he would gain of these wonderful and frequently very beautiful structures if he were to visit the Natural History Museum at South Kensington, and inspect the admirable collection of different types of these and other marvellous animal structures arranged in the cases placed in the bays on the left side of the great central hall.

Our necessarily brief and hurried glance at some of the more important types of animal armour will be best understood if we take the various groups in their natural sequence of rank and their succession in geological time, commencing with the lower and earlier forms. Our first glance will then be directed towards the great class of fishes, of which some of the earliest examples occur in the Old Red Sandstone of Scotland, which was laid down in lakes and rivers ages before those forests flourished which formed the wood

and foliage we now burn in our fires as coal. Strange and uncouth must have been many of these old fishes, whose bodies were encased in a complete coat of plate-armour unlike that found in any living forms, and consisting of larger or smaller shield-like bones closely united together at their edges. The head, too, in some of these fishes (Fig. 1.) was most remarkable, and looked something like

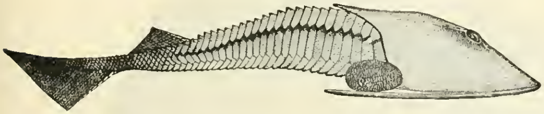


Fig. 1.—An Armoured Fish (*Cephalaspis*) of the Old Red Sandstone.

a flattened and expanded plough-share. It has been suggested that the reason why these earlier fishes possessed such an extraordinarily strong coat of mail is that the waters of these primeval epochs were hot from contact with the still heated globe, and were also impregnated with strong acids or salts; but it does not appear that it would be any advantage to be boiled in a coat of mail rather than in an ordinary skin. Somewhat later in the world's history, that is to say at and about the period when our coal was formed, fishes with an armour of a different type were very abundant; many of the same groups also occurring in the Old Red Sandstone. In these Ganoid fishes, as they are scientifically termed, the body (Fig. 2) was often covered with

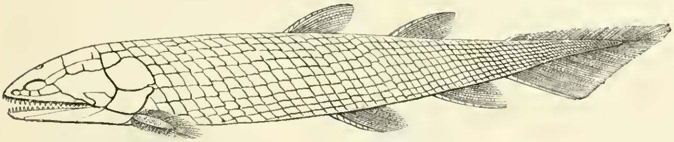


Fig. 2.—A Ganoid Fish (*Osteolepis*) of the Old Red Sandstone, showing Plate-armour.

a coat of lozenge-shaped scales, formed of bone and faced with a hard coating of shining and polished enamel. These scales did not, as in the fishes of the present day, overlap one another like the slates on a roof, but were joined together at their edges, frequently with the aid of a peg from one scale received into a socket in the adjacent one. Fishes with this form of plate-armour flourished not only in the Coal period but were also abundant at that later date when the blue Lias clays of the cliffs of Whitby and Lyme-Regis were laid down on the old sea-bottom. After that, however, this type of armour seems to have gradually gone out of fashion, and the only fish in which it now remains is the Gar-pike of the American rivers, which may thus be regarded as a kind of mediæval knight. The Sturgeons, known to many of us chiefly or entirely through that Epicurean luxury *caviare*, present us with another type of armour, which is probably a survival from long past days. In these gigantic fresh-water fishes the body is protected by several longitudinal rows of large diamond-shaped bony plates, which are not connected with one another. Whether, however, this modification of plate-armour is derived from a complete suit, and is thus somewhat analogous to the Life-Guardsman's cuirass, or whether it was always of the same type as at present, is one of those questions which does not at present admit of a decisive answer. In contrast to the Ganoid fishes, where we see a gradual dying out of the old mail-clad types, we may notice the case of the Sharks and Rays. These fishes seem to have taken a moderate course in regard to armour, avoiding on the one hand the plate-armour of the Ganoids, and on the other the light scale-armour of the fishes of to-day. In most of these fishes the skin is studded with very small bony granules, and thus has a rough file-like structure, being commonly known to us under the name of Shagreen. These fishes, be it noted, while among the earliest known forms, are still extremely abundant, and thus present a striking instance of the advantage of a middle course in the struggle for existence.

By far the great majority of the fishes of the present day belong, however, to a group which seems to have made its appearance shortly before our Chalk was deposited, and is now the dominant one. These modern fishes have succeeded in entirely getting rid of the plate-armour of the Ganoids, for which they have substituted a much lighter scale-armour formed of the well known over-lapping horny scales which give the silvery lustre we admire so much in the roach and salmon. The same type of armour also obtains in the Barramunda of Queensland (Fig. 3), which

Fig. 3.—The Barramunda (*Ceratodus*) of Queensland, showing overlapping Scale-armour.

belongs to an older group. Whereas, however, the majority of the fishes of the present day have adopted this light scale-armour in place of the old-fashioned plate-armour, a few have struck out a new line in the development of a different type of bony coat of mail. Thus the tropical Coffer- and File-fishes have a protective coat of bony plate-armour with a sculptured outer surface, so locked together as to form a box-like structure investing the entire body. Again, among the fresh-water Cat-fishes there is one genus in which the body is covered by a cuirass of overlapping plates formed of solid bone. Perhaps, however, the most peculiar kind of armour in the entire class is found among some of the well-known Globe-fishes, which are also so remarkable for their habit of inflating their bodies into a balloon-like shape. In these fishes, as is shown by a preparation in one of the cases already alluded to in the Natural History Museum, the body is protected by a coating of long spikes, each of which may be as much as two inches in length, and is inserted in the skin by a flat and expanded plate of bone.

As a whole, then, in spite of the exceptions last mentioned, which according to the time-honoured phrase only serve to prove the rule, the fishes appear to have come to the same conclusion as the more advanced divisions of the human race, that a massive armour for the protection of the body is an encumbrance rather than an advantage as a means of protection against attack.

The same story is told still more clearly in that group of animals now represented by the frogs, newts, and their allies, which are popularly reckoned among Reptiles, but which Naturalists, with that tendency to multiply terms for which they are so celebrated, distinguish as Amphibians. Thus during and for some time after that distant epoch to which we have already referred, when the coal forests waved over what is now Britain, there lived a number of newt-like Amphibians, termed, from the complicated internal foldings found in the teeth of many of them, Labyrinthodonts. In these creatures, of which the petrified footmarks are often found in the sandstones of

Cheshire, the under surface of the chest was protected by three large bony plates; while in some cases an armour of scale-like bones covered the rest of the body. All the existing frogs, newts, and such-like creatures have, however, totally dispensed with the panoply of their forefathers; and have, as we all know, a soft and naked skin.

The true Reptiles, in which the Naturalist includes crocodiles, lizards, snakes, tortoises, and turtles, as well as a host of fossil extinct forms, appear, speaking metaphorically, to have held divided opinions as to whether a bony coat of mail was or was not a thing to be retained as a permanency; since, while some extinct and early groups never had any armour, others have continued this protective covering in great perfection to the present day. Reptiles are, moreover, remarkable for the great variety of the kinds of armour which they have displayed in the course of a long career.

The Crocodiles offer the best living examples of reptiles with a plate-armour, recalling that of some fishes. In these fierce creatures, the back and upper surface of the tail is covered with a number of oblong bony plates buried in the skin and covered by horny shields. In the true crocodiles (which in India so many people will insist on misnaming alligators), this armour is confined to the upper surface of the body; but in some, although not in all, alligators, there was also a similar armour upon the lower surface. Since, moreover, most of the earlier fossil types had an armour upon both aspects of the body, it seems that crocodiles have, on the whole, found it advantageous to get rid of the lower buckler, so that to a certain extent they seem to have followed the general rule. It is, however, very curious to find that there were some fossil crocodiles which totally discarded their armour; and have since these altogether disappeared, it would seem that this radical change did not answer in this particular instance.

As first cousins of the crocodiles, we may briefly note, then, fossil reptiles to which, from the gigantic size of some of them, the name of Dinosaurs, or Terrible Lizards, has been applied. Some of these huge creatures, which far exceeded the elephant in bulk, had a bony armour which formed a solid cuirass over part of the back and loins; while in many cases the bony plates which covered the body were developed into huge spikes of more than a foot in length.

The Lizards and Snakes, which we may regard as advanced and highly specialised reptiles, having but little kinship with the old-fashioned Crocodiles and Dinosaurs, have, as a rule, discarded the plate-armour of the latter, and have acquired instead a light scale-armour of overlapping horny scales, which are beautifully marked in many of them. The snakes, indeed, never have any trace of the bony plate-armour, which would, of course, interfere with their lithe motions; but in some lizards, small rudimentary bony plates are found in the skin underlying the scales, to tell the tale of their old alliance.

Perhaps, however, the most original idea in the way of a coat-of-mail is found in the Tortoises and Turtles. In these reptiles, the ribs and back-bone of the skeleton have taken part with bony plates, analogous to those of the crocodiles, to form a solid armour which in the land-tortoises (Fig. 4) is welded together into a complete box, from which the creature can only protrude his head, tail, and limbs. This remarkable and unique arrangement has entailed the further curious modification that the shoulder-blade and haunch-bones are placed inside the ribs, instead of externally to them, as in all other animals. This type of armour, which we may term box-armour, seems to have been a success, since tortoises and turtles are, in certain parts of the world, among the commonest of reptiles. In some of those types which are dwellers in water, such as

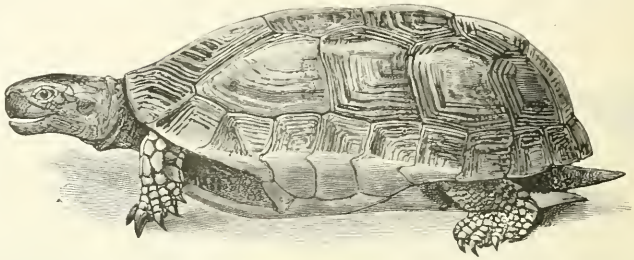


Fig. 4.—A Land-Tortoise, showing the complete Box-like Shell.

the well-known soft tortoises, or mud terrapins, so abundant in the Nile and other tropical and subtropical rivers, the breast-plate and the back-plate of the armour are, however, quite separate from one another, this arrangement, probably, being more conducive to freedom of action in swimming.

The great class of Birds, which Professor Huxley calls only highly modified reptiles, are remarkable in that there is no trace of a coat-of-mail in any single species. And when we come to consider the life which these creatures lead, we at once see the absence of any need for such a protection. Thus it is quite clear that in ordinary birds, which are gifted with the power of flight, a bony armour would not only be perfectly unnecessary as a protection but would also seriously impede, if even it did not totally prevent, their flight. On the other hand, in the flightless birds, like the ostriches and their allies, or the kiwis of New Zealand, sufficient protection is afforded either by their size and strength, or by their nocturnal habits. There are, indeed, certain flightless species, like the extinct dodo, of Mauritius, which have neither strength nor speed, nor are of nocturnal habits. Their want of the power of flight is, however, an acquired loss, due to their dwelling in islands in which they are, or were, free from the persecution of enemies, and thus needing no special protection of any kind.

Leaving the birds, we have to complete our brief and hasty survey of the various types of armour obtaining among vertebrate animals by a glance at that class which includes the highest of all vertebrates, and indeed of all animals. Unfortunately we are still in want of a good popular name for this class, which includes man himself. In common parlance these animals are, indeed, very generally termed quadrupeds. But this name is objectionable, in that it is equally applicable to many reptiles, and also since it can scarcely be applied to whales, which, as is well known, belong to the same class as man. The term Mammals is, however, becoming somewhat popularised in the sense of the older term quadrupeds, and, since it is in every way an excellent one, we shall make no apology for its use. Now, with the exception of one peculiar group or order, all mammals agree with birds in being conspicuous for the absence of a bony bodily armour; and since they have not the peculiar means of protection possessed by so many of the latter class, they afford striking examples of our thesis that as animals have progressed in organization they have discarded protection by plates of bone, to find a better one in the strength or

speed of their limbs, or in the sharpness of their teeth and talons.

The solitary group of mammals which has sought protection in a coat-of-mail is the one which comprises the sloths, ant-eaters, and armadillos. Only a few, however, of these creatures have thus protected themselves; while some, like the sloths, have sought refuge in an arboreal life; and others again, like the ant-eaters, have found protection by burrowing in the ground. These mammals, which are scientifically known as the Edentates, are all of a very low type of organization, and widely different from all other members of the class. It is, however, noteworthy that low as they undoubtedly are, yet that they exhibit no signs of relationship with the lowest of the mammal class, such as the Australian duck-mole. Since, moreover, the duck-mole and its allies have no coat-of-mail, it is further evident that the Edentates have not inherited their armour from lower forms, but that they have evolved it themselves *de novo*.

The Edentates having however, so to speak, once made up their minds that armour is the right thing have gone in for it with a will, with the result that they show some of the finest specimens of plate-armour to be found in the whole animal kingdom. In the comparatively small armadillos of America, which are the best known examples of the armoured Edentates, the whole of the body, with the exception of the under surface, is protected by a very strong bony armour, which is often elegantly sculptured. Thus their shoulders are encased in one solid shield, and their loins in another, the two shields being connected by a series of movable transverse bands, which permit the creature to roll itself up into a ball after the manner of a hedgehog, and thus present a sphere of plate-armour to an enemy. Still more wonderful, however, is the armour of the extinct Glyptodonts (Fig. 5) of South America, in

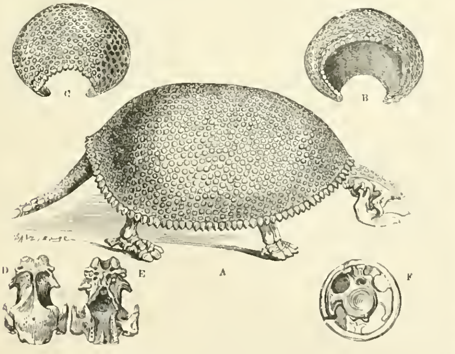


Fig. 5.—A Glyptodont Edentate, showing the Carapace. A, View of entire animal. B, Front end of carapace. C, Back view of same. D and E, Upper and under side of skull. F, Section of tail showing caudal vertebræ inside the bony sheath.

which the shield formed a single solid carapace, which may be as much as five feet in length, and with a thickness of more than an inch of solid bone. These creatures could not, of course, roll themselves up, and they therefore had their tails protected by a coating of bony rings closely articulated together. Moreover, some of them had a breast-plate on the under surface of the body, of which it is not very easy to see the necessity, since this aspect would not be exposed to attack. The huge carapaces of these Glyptodonts are often found on the Pampas, where they are said to be used as shelters by the natives. One would have thought that with such an armour the breed of Glyptodonts would at least have lived as long as the puny armadillos; but their extinction in long past epochs repeats the lesson that the race is not always to the swift, nor the battle to the strong.

Finally, as a last and very original type of mailed animals, we must mention the scaly ant-eaters, or pangolins, of Africa and Asia, which (pursuing our metaphor) appear to have come to the conclusion that a bony plate-armour is much too heavy for such warm climates, and have, therefore, adopted a light and elegant scale-armour composed of overlapping brown, horny scales, causing them to look much like an elongated cone of a spruce-fir endued with life. Even, however, this lighter and last type of armour does not appear to have been altogether a success in life's battle, since pangolins are comparatively scarce animals, few in species, and dragging on what seems to us a somewhat dull existence by the aid of nocturnal and burrowing habits.

THE COMMON FLEA.

By E. A. Butler.

Notwithstanding his elevated position in the animal creation, man is no more exempt—humiliating though the confession may be—from the attacks of personal parasites than other animals; but of the various species that link their fortunes with his, and subsist upon his person, fleas seem less dependent than any others upon uncleanly conditions and habits of personal neglect on the part of their host, and hence they are not restricted to the lower strata of society but become a universal nuisance. The ever-present desire to exterminate them, no doubt, operates powerfully against their being minutely studied, and hence very little seems to be generally known about their structure, habits, and life history, beyond what painful experience teaches. And yet they are really extremely curious creatures, and were it not for the popular prejudice against them, they would, no doubt, attract the attention they deserve: it is no exaggeration to speak of them as zoological oddities. There are many different kinds besides that particular species that infests man; they have been observed on various mammals, especially small ones with thick fur, or hair, such as moles, shrews, squirrels, mice, rats, dormice, hares and rabbits, as well as on dogs and cats. Many birds also are infested by true fleas, in addition to their own proper parasites, the bird lice. The species which attack these different hosts seem to be distinct, each animal, as a rule, supporting its own special parasite, but they resemble one another so closely that they form a perfectly natural family, which is called *Pulicidæ*, from the principal genus *Pulex*. On the other hand, in their most characteristic peculiarities they are utterly unlike any other insects, and hence have been a great puzzle to systematists. It is not easy to find a suitable corner for them in our schemes of classification, and many have got over the difficulty by placing them in an order by themselves, which, from the apparent absence of wings, has been called Aphaniptera (without distinct wings). Others have, however, seen in them some affinities to the two-winged flies, or Diptera, and have located them somewhere in that order; but here again there has not been unanimity, and some have placed them at the end, while others have inserted them in the body of the order, following the *Mycetophilidæ*, a family of small flies which possess considerable jumping power, and live gregariously amongst decaying vegetable matter, or in fungi,

dung, &c. That their affinities are strongest with the Diptera is now generally recognised, and they are therefore regarded as a sort of apterous flies, which have addicted themselves to parasitic habits. The reasons for this opinion will become evident as we proceed.

Having premised thus much as to the zoological position of the group, we may now endeavour to get a clear notion of the structure of *Pulex irritans* (Fig. 1), the common human flea, so-called, and afterwards deal with its life history. In the shape of their body, fleas are quite exceptional; it is flattened from side to side, so that when the insect is standing upright its greatest diameter is the vertical one; this form of body is called "compressed"; it is exactly the reverse of what obtains in that other nocturnal pest, the bed-bug, whose body is flattened in the vertical direction, and whose greatest diameter is the transverse; this shape of body is called "depressed." Certain fishes present similar extremes of structure; thus a skate is depressed, but a plaice or sole compressed. The flea's body is covered with a hard, slippery, reddish brown chitinous skin, showing plainly enough the division into rings or segments which characterises insects and other annulose animals. The head, which is rounded above, is small in proportion to the size of the insect, and is followed by three small and separate segments which represent the thorax; these are again succeeded by several much larger segments forming the abdomen, which, in the female, is at least three times as deep as the head. To the thoracic segments are attached, as usual, the three pairs of legs, which increase in length from before backwards.

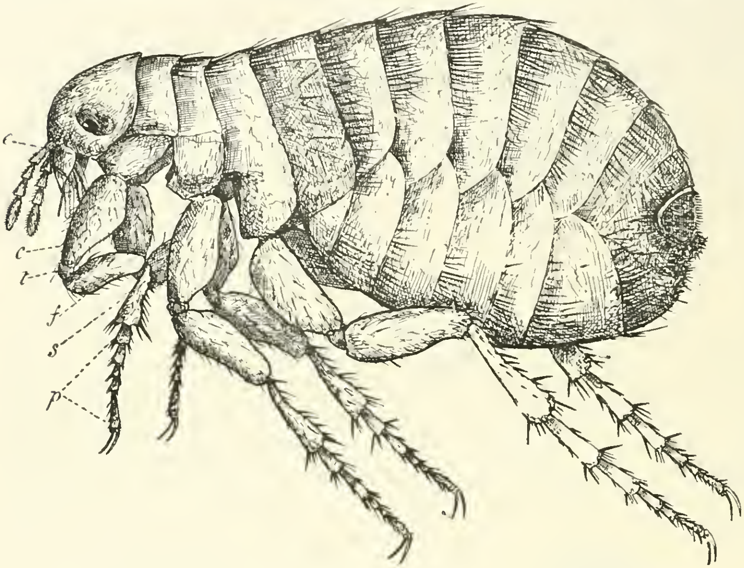


FIG. 1.—COMMON FLEA (Pulex irritans), female; *e*, epimeron; *c*, coxa; *t*, trochanter; *f*, femur; *s*, tibia; *p*, tarsus.

The legs are remarkable in several ways. At first sight they seem to have an extraordinary number of joints, and yet the parts are exactly the same as in insects generally, and follow the plan typified in the cockroach. It will be remembered that that joint of an insect's leg by which the limb is attached to the thorax is called the coxa. Now the coxæ of a flea are not only enormously large, being indeed the broadest and almost the longest section of the leg, but they are also far more completely freed from the thorax than is usually the case, being only attached by one extremity; this causes the leg to appear to have an extra joint. But this is not all; in the first pair, especially, we seem to have yet another additional joint, and this appearance is due to the fact that the *epimera* (viz. those elements of the thoracic segment to which the coxæ are directly attached) themselves project from the body of the segment, and point obliquely forwards. These arrangements give an extremely awkward appearance to the legs, but no doubt facilitate the leaping process. The trochanter is small, and both femur and tibia are about the same length as the coxa; but the tarsus, which, like that of the cock-roach, consists of five joints, is remarkably long, and is terminated by a pair of long curved claws, which the insect must find extremely useful as it works its way about amongst the garments of its host, or between the bed-clothes. Most leaping insects have the hind femora very largely developed, since in them are placed the muscles which originate the impulse of projection; this arrangement is especially noticeable in grasshoppers, and in the tiny beetles called turnip fleas, which do so much harm to cruciferous plants. The hind legs of the flea, however, scarcely differ from the other pairs except in length, and the proportionate dimensions of all three pairs are much the same, all having coxæ larger than would be requisite for a walking insect. All parts of the legs are beset with bristly hairs, those towards the end of the tarsus being especially closely packed. The abdominal segments also are furnished with bands of long, stiff hairs across the back. No doubt these hairs—all pointing, as they do, away from the head—aid the flea, quite as much as its compressed form, in its endeavours to insinuate itself into the small spaces between our garments it has often to travel along in order to reach its pastures; and help, at the same time, to explain the difficulty that one experiences in attempting to hold the insect between finger and thumb.

Turning now to the mouth organs (Fig. 2), we find a far more complicated apparatus than might have been expected. The type of mouth is that called suctorial; *i.e.* it is adapted, as we are painfully aware, for the swallowing of liquid food, obtained by a process of perforation. In this respect fleas agree with flies, and, for the matter of that, with bugs; but are totally unlike bees, wasps, and ants, to which group of insects some people have thought they show some affinity. The labrum, or upper lip, seems to be represented only by a slender saw-edged bristle, which is perforated throughout its length by an exceedingly minute canal. This is situated in the centre, and

on each side of it are the mandibles, in the form of two straight flat blades, pointing downwards, and notched on each side like a double saw. The mandibular teeth number about 75 in each row on each side, which, at the rate of two double rows to each mandible, gives a total of some 600 glistening tooth-like projections on these

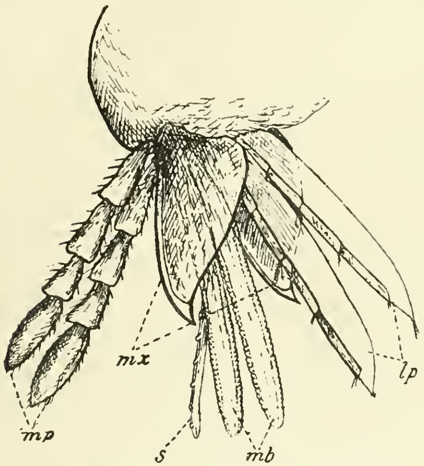


Fig. 2.—Mouth Organs of Flea; *s*, labrum; *mb*, mandibles; *mx*, maxilla; *mp*, maxillary palpi; *lp*, labial palpi.

weapons alone. The maxillæ are two sharp-pointed triangular pieces, which, when seen in profile, as in a specimen mounted for the microscope, have the appearance of a sharp beak; they are furnished with a pair of long four-jointed palpi, which project in front of the head, and might easily be mistaken for antennæ. The labium is reduced to a small membranous plate, which carries a pair of palpi, not quite so large as those of the maxillæ; each of these is formed into a keen blade on one edge, and rather obscurely jointed into four on the other. It is not easy to say exactly how these organs are used, since whenever we are consciously subjected to their operation, we are more anxious to get rid of the operator than to examine minutely into its method of proceeding. The whole evidently constitutes a piercing apparatus of exquisite delicacy, and the mandibles are no doubt the most effective part. We are accustomed to speak of *fleabites*, but this is scarcely a correct way of designating the operation; the appendages of the mouth are not in any sense biting organs; the action is that of vertical piercing, not lateral pinching or nipping. In possessing palpi fleas agree with flies, and differ entirely from the other chief order of insects with a piercing, suctorial mouth, viz. the bugs, which are never provided with such organs. On the other hand, in possessing both labial and maxillary palpi they differ from the ordinary flies, which are furnished with the latter only.

In the structure and arrangement of their organs of sense, again, fleas justify our statement that they are zoological oddities. While the eyes of flies are compound, each mass often containing thousands of facets, those of fleas are simple, and consist only of one rounded knob on each side; and as most of the insects' predatory operations are carried on in either partial or total darkness, it would seem that even these numerically reduced visual organs are of no great avail in the obtaining of food. The eyes are placed in the front of a hollow space, in the hinder part of which the antennæ are lodged; these are short, curiously shaped organs, and are so obscurely situated that they would certainly escape notice unless carefully looked for. (Fig. 3 represents the antenna of a dog's flea, and that of the human pest is very similarly shaped.) The hollow in which they lie is partially covered by an extension of the chitinous integument of the head, and the part still left open is further protected at a lower level by a membranous flap, which can be pushed aside when the antennæ are protruded. Their extraordinary shape, as well as their concealed and guarded position, indicates that many interesting problems await solution as to their functions and the particular uses of the several parts.

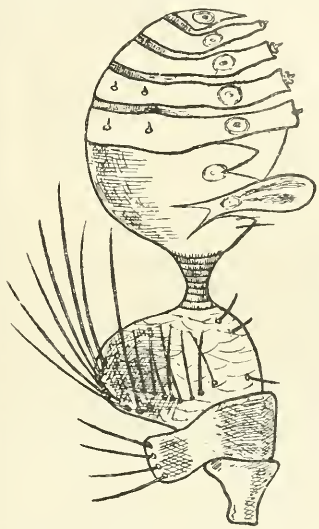


Fig. 3.—Antenna of Dog's Flea (Pulex canis). After Landois.

The last two thoracic segments carry a rounded scale on each side, projecting from their hinder edge. The first is a minute one, but the second very much larger, overlapping parts of the first two abdominal segments. They are apparently rudimentary wings.

Fleas sometimes exist gregariously on their hosts, and those of the lower animals especially have the habit of attaching themselves most pertinaciously to some part of the body from which no effort of their host can dislodge them. Some years ago, Mr. Verrall exhibited before the Entomological Society a colony of living fleas which had been taken shortly before from the inside of a rabbit's ear, where they were congregated on a spot from which the animal could not remove them by scratching. The neck of a fowl, again, is another place on which large numbers of a certain species have been found, collected in a small area, with their lancets buried deep in the flesh. They are not slow to discover when their host can furnish them with no further nourishment, and it is curious to notice how soon they abandon a dead body. This may easily be observed in the case of the cat's flea; if a recently defunct cat be watched, as the body becomes cold and stiff, the fleas will soon be seen struggling out from amongst the fur, though not a single specimen may ever have been seen as long as the animal was alive and warm, and its blood therefore readily obtainable.

The human flea is reputed to be pugnacious, and one observer, who had confined a couple of females in a glass tube, in order to induce them to deposit eggs, describes them as immediately becoming "rampant, confronting one another like microscopic kangaroos."

Fleas are peculiar amongst parasites as being parasitic only during one stage in their career. It is only the fully-grown insects by which we are troubled, and though we find them of different sizes, little ones and big ones,

it must not be supposed that the former are merely younger forms of the latter. A flea has not throughout its life the form with which we are familiar, nor does it in that form grow at all. The little fleas are simply the males, which are considerably smaller than the females, in accordance with a rule very frequently illustrated amongst insects. The males also differ in shape, and have the hinder end of the body somewhat turned upwards. In its life history a flea differs totally from a bug; the former is an insect with a complete metamorphosis, and therefore altogether differently shaped in its larval condition, while the latter is almost identical in shape during the whole of its life, and exhibits similar habits throughout; hence the tiny bugs are really young ones, though this is not the case with fleas.

(To be continued.)

ON THE SCINTILLATION OF STARS.

By A. C. Ranyard.

If a large star near to the horizon is watched by an ordinary long-sighted person,* it will be noticed that its light is not steady, but that three classes of changes are continually taking place. The brightness of the star increases and decreases. Its light changes in colour, and the central bright point appears to dance or jump about. All these changes put together make up the phenomenon known as scintillation or twinkling, which is so evident, even at considerable altitudes, that most people are able to recognise planets by the steadiness of their light which does not scintillate or twinkle.

In order to see the changing colours to the best advantage, let anyone direct a small telescope to a star not very far from the horizon, and, having focused it sharply, let him tap the eye-piece or body of the telescope so as to make it vibrate. To the observer the star will appear to move, and not the telescope. It will appear to be drawn out into a line of light as the eye follows the motion of the edge of the field of the telescope, and the star is projected upon different parts of the retina. If the telescope is a small one, and vibrates rapidly so that the period of its swing does not occupy more than about a third of a second, the star will appear to describe a closed orbit, generally either an ellipse or a circle, along which the different colours repeat themselves very brilliantly. M. Montigny of Bruxelles has utilised this method for comparing the amount of scintillation on different nights, and for the same stars at different altitudes. His instrument, which he calls a scintillometer, enables him by whirling round a small disc in front of the eye-piece to make the image of a star appear to describe a circle in the field of the telescope, upon the circumference of which he counts the number of times that the colours are repeated; and the rate of motion being known, he calculates the number of changes of colour per second.

* I am careful to restrict the description to what is seen by long-sighted people, for short-sighted people see the stars as discs or patches of light on the sky. They see a bright disc for a large star, and a duller disc of about the same diameter for a small star. Many people go through life without knowing that the stars are seen by their neighbours as points of light, and to such people the phenomena of scintillation are much less perceptible. If a long-sighted person wishes to realise how a short-sighted person sees the heavens, let him take an opera-glass and look at the stars with it when out of focus. and a short-sighted person may realise how a long-sighted person sees the stars by focusing the opera-glass until the star images all appear as bright points. He will then be able to see the phenomena of scintillation as described above.

Authorities differ as to the exact cause of scintillation. Let us, therefore, examine closely the facts that may be observed, and study the conditions under which the light of a star reaches us. If the spectrum of a star rising in the east be examined, darkish bands are seen rapidly traversing the spectrum from the blue to the red; and, on the other hand, in the spectrum of a star setting in the west the dark bands traverse the spectrum from the red to the blue end. When a star is on the meridian the bands sometimes traverse the spectrum in one direction, and sometimes in the other, and sometimes they swing alternately to and fro. We evidently have in the regular motion of the bands in the light of a rising or setting star a phenomenon connected with the earth's motion on its axis; while in the irregular motion of the bands in the spectrum of a star on the meridian we seem to have a phenomenon connected with the direction in which the winds are blowing. If there are masses which cause unequal refraction in the air, they would cause the light of the star to be concentrated in some places and turned away from others. If we consider only one of the rays of the spectrum, say a blue ray, and the light of the star were strong enough, it would illuminate a surface much as the shallow bottom of a rippling pool is lit up by the sun, causing light and dark mottlings, which appear to move along with the ripples on the surface. Each ray will be differently refracted, and consequently the blue and the red mottlings will overlap and be constantly changing. If we trace backward from the eye the different rays of the spectrum through the air it will be seen that the violet ray, which is most refracted, must have entered the air at a greater height than the red ray, and we may calculate the distance between the two rays at various altitudes. The different behaviour of the two rays shows that many of the refracting masses in the air are small compared with the separation of the different coloured rays, and that the refraction causing the dark bands in the spectrum must take place at a considerable altitude. This also is evident from other considerations.

The various coloured rays from the star are carried athwart the refracting masses as the star rises, and the violet ray will be the first to be affected by any particular refracting mass—it will then successively affect the blue, the green, the orange, and the red, and, as we have seen with a rising star, a dark band passes down the spectrum from the violet to the red end. We can calculate the rate at which these rays sweep across a refracting mass at any distance from the observer—as was explained in the article on Mountain Observatories in the April number, a line from a star to the eye of the observer sweeps onward like the hand of a great clock, which makes one revolution in twenty-four sidereal hours. At a distance of 25 miles from the observer the thwart motion of the rays through the air (if no wind were blowing) would be about 9 feet 7 inches per second, or a little more than 6 miles an hour — a velocity which is small compared with the average velocity of the wind in the upper air. Thus M. Angot gives the average velocity of the wind at the top of the Eiffel Tower—994 feet above the ground—as 16 miles per hour, while the average velocity during the 101 days of observation, measured with a similar instrument placed 66 feet above the ground at the Paris Meteorological Office, was only 5 miles an hour. At greater heights the wind velocity is probably still greater, for example, we know that the dust from Krakatoa was carried to Trinidad, half round the earth, in seven days, showing an average westerly velocity of 80 miles miles per hour. The regular drift of the dark bands in the spectrum of a rising or setting star shows that the

velocity with which the rays are carried athwart the refracting masses is large compared with the velocity of the wind, or rather is large compared with the velocity of the wind across the line of sight. At a distance of 50 miles from the observer the rays from a star sweep through still air with a thwart velocity of about 12 miles an hour, and at a distance of 100 miles from the observer with a thwart velocity of 24 miles an hour.

Let us now consider the separation of the different coloured rays coming from a star at different distances from the observer. Ketteler gives, in the *Fortschritte der Physic*, 22nd *jahrgang*, p. 179, the refractive index for the B ray on passing from vacuum into air at a barometrical pressure of 0·76 met. as 1·00029350, and the refractive index for the G ray, under similar circumstances, as 1·00029873. Dr. J. H. Gladstone, who has made the subject of refractive indexes a special study, tells me that Ketteler's measures, though dating back to 1865, are still perhaps the best in regard to the dispersion of gases. According to these measures, it may be shown that for small deviations the dispersion of the G and B rays amounts to about $\frac{1}{60}$th of the atmospheric refraction.

We know that at a height of 45° above the horizon the atmospheric refraction amounts to nearly 1′, at a height of 27° it is nearly 2′, and at a height of 10° it is about 5′, and the horizontal refraction ranges from about 34′ to 39′. Consequently the deviation between the G and B rays, at sea-level, for these altitudes is about 1″, 2″, and 5″ (34″ to 39″) respectively. The greater part of the deviation is caused in the lower atmosphere; we may therefore be sure that the actual path of the rays lies closer together than two lines inclined at the angle of dispersion with which the rays enter the observer's eye. Consequently, for a star at an altitude of 45° (at which altitude scintillation is very evident) the violet ray G of the spectrum will, at a distance of 25 miles from the observer, be within 7½ inches of the red ray B, which, on reaching the observer's eye, will merge with the G ray in making up the image of the star. At a distance of 50 miles from the observer, the distance between the two rays will be less than 1 foot 3 inches. We know that the two rays suffer very different refraction—for one part of the spectrum is dimmed while the other is bright; we may therefore be sure either that the diameter of the refracting masses is small, or that the refraction is caused at a very great height in the atmosphere.

We have at our disposal another means of estimating, in a rough and general way, the diameter of the refracting masses which deflect the rays, much in the same manner as the distance between the waves on the surface of water might be estimated by a fish whose eyes would only permit him to look at the bottom. He might form an estimate of the average size of the waves, by observing the average distance between the bright and dark mottlings of sunlight on the bottom—so we may get some notion of the size of the refracting masses by looking at the disc of light which corresponds to the image of a bright star when out of focus in a large telescope. This disc of light is never perfectly uniform and tranquil; under certain conditions it seems almost to boil, the agitation is so great. Each part of the disc receives light from a different part of the object glass (or of the speculum, if the instrument be a reflector), and it is evident, from the dark patches continually passing across the disc, that less light from the star is falling on some areas of the object-glass or speculum than on others. With an 18-inch reflector, with which I have observed, one sees in the centre of the disc a black circular patch corresponding to the flat which reflects the light to the eye-piece. Dark and bright patches are continually passing across the luminous disc. As a general rule, they move parallel to one another. If they took a second to pass across the whole 18 inches, the actual velocity at right angles to the direction of the star of the refracting masses producing the patches would be a foot and a half per second, or a mile an hour. They usually pass more rapidly than this, but not so rapidly that the eye cannot follow them.

It has frequently been suggested that the refracting masses may be due to aggregations of aqueous vapour in the air; and it has been pointed out that the masses of aqueous vapour which become visible as cloud in the lower air are large, and that as you ascend the cloud masses become smaller and smaller; but the small refracting masses which produce the black bands which flit across the spectrum, and the black patches which move across the illuminated image of an object glass or speculum, cannot owe their difference of refracting power to excess or defect of aqueous vapour. If such aggregations of aqueous vapour were possible in the air, they would not produce the observed irregularities of refraction. For, according to Jamin (*Ann. Ch. Phys.* [3] xlix. 382), the difference between the refractive index of dry air and air saturated with moisture at 20° C. is only 0·000000726, a quantity which, as Dr. Gladstone (to whom I am indebted for the reference) says, "may safely be neglected for astronomical purposes."

But the difference in the refractive index of air is materially altered by a change of temperature—an increase of one degree Centigrade in the temperature of a mass of air increases its volume (the pressure remaining the same) in the proportion of 1 to 1·003665. Its density is therefore decreased in similar but inverse proportion, or as 1·003665 to 1, and we may calculate the change in the refractive index from the law $\frac{\mu-1}{d}$ = a constant.

In ordinary language this law may be stated thus. The excess of the index of refraction over unity, or the "index of deviation" (as Sir G. B. Airy happily christened the quantity $\mu-1$) varies as the density, or varies inversely as the volume of a mass of gas when the pressure does not change.

A decrease of temperature of one-hundredth of a degree Fahrenheit will cause a mass of air to decrease in volume in the ratio 1·00002036 to unity, and the focal length for parallel rays of a spherical lens of radius r and refractive index μ is $\frac{\mu r}{2(\mu-1)}$. Therefore a spherical mass of cooler air of one foot radius and one-hundredth of a degree Fahrenheit below the surrounding air, would bring parallel rays to a focus at a distance of $\frac{1\cdot00002036}{2(0\cdot00002036)}$ ft., that is, at a distance of a little less than five miles.

At a distance much less than five miles, or at a distance much greater than five miles, the concentration of light by such a spherical mass of cooler air would not make itself apparent; but the deviation caused in the direction of transmitted rays will be the same whether the mass of denser air is near or far from the observer.

We know, from the fact that the red and the blue rays coming from a star are very differently affected by the refracting masses, that they cannot be large in diameter compared with the distance between the path of the red and blue ray; and the small areas dimmed by them on the object-glass of a telescope also point to the conclusion that the masses are generally not many inches in diameter. We also know that the refracting masses which produce

the bands that pass regularly across the spectrum of a rising or setting star must be very distant from the observer, or they would not in general be affected by the earth's rotation rather than by the winds blowing. We are therefore driven to the conclusion that the difference of the temperature, between the masses of air causing the unequal refraction and the surrounding air, must be small compared with the hundredth part of a degree Fahrenheit.

Notices of Books.

Diseases of Plants. By H. MARSHALL WARD, M.A., F.R.S. (Christian Knowledge Society.) We cannot conceive of a better introductory text-book on the subject of plant diseases caused by micro-fungi than this new volume of the "Romance of Science Series," nor could the subject have fallen into the hands of anyone better fitted than Prof. Marshall Ward to popularise it without in the slightest degree deviating from scientific accuracy. There is a freshness of style, a terseness and felicity of expression, and a lucidity of exposition that is quite fascinating, and that entices the reader on through chapter after chapter, as he follows the author in his description of the romantic adventures of first one kind of fungus spore and then another. A book which details with minute accuracy the life history of such scourges as the "potato disease," caused by *Phytophthora infestans*, the "hop-mildew," and the "smut," "rust," and "ergot" of cereals, cannot fail to be of interest and value to all practical men. If to be fore-warned is to be fore-armed, and if to know one's enemy is the best possible preparation for taking measures to protect oneself against him, then this book ought to be in the hands of every practical horticulturist and agriculturist of any pretensions, and to be diligently studied from end to end. The paper, typography, and illustrations are everything that could be desired.

Toilers in the Sea. By M. C. COOKE, M.A., LL.D. (Christian Knowledge Society) This is something more than a mere popular exposition of the wonders of marine invertebrate life, and many who have long been students of the fauna of the sea will be grateful to Dr. Cooke for having gathered into convenient compass so complete an epitome of the results of modern research—results which are scattered through such a wide series of scientific journals that access to a good library and many hours of patient search are often necessary for the verification of facts. The scheme of the work has necessitated that only those groups of invertebrates should be included which possess solid parts capable of preservation in the dry condition, and in the investigation of which the microscope will be largely used; hence Foraminifera, Polycystina, Sponges, Sertularian Hydroids, Corals, Alcyonarians, Polyzoa, and Tube-worms are the only groups discussed. Notwithstanding Dr. Cooke's defence of the title he has selected, we still think that, as very few of the structures referred to are really marine "Homes without Hands," it would have been better to have avoided an expression which in almost every case suggests a wrong relation between the object described and the animal of which it formed a part. This, however, is a minor point, and there is little in the book itself but will tend to dissipate the too commonly received notion that such structures as coral, for example, are formed by the united *efforts* of numbers of minute creatures which *toilingly* raise, little by little, structures which ultimately reach gigantic dimensions. The book is delightfully written and well illustrated, and contains an enormous amount of information from the best possible sources. To amateur microscopists especially we would most cordially commend it, and we feel sure that if they will only take it as the companion to their favourite instrument, they will be able to form far more intelligent ideas concerning the nature of many of the beautiful objects which are popular in microscopical exhibitions, than are at present, unfortunately, generally to be met with.

Wayside Sketches. By F. E. HULME, F.L.S. (Christian Knowledge Society.) This is a book of gossip, on an endless variety of subjects connected with rural life and the round of the seasons; but it descends, we fear, too frequently to the level of commonplace, and the chapters are far too long. The illustrations, nearly seventy in number, are a redeeming feature, being varied in subject, and, as a rule, accurate and artistic in execution.

GROWTH AND DECAY OF MIND.

By THE LATE R. A. PROCTOR.

(*Continued from p.* 231.)

IT cannot be questioned that with old age there comes a real physical incapacity for original work, while the power of maturing past work remains comparatively but little impaired. Dr. Carpenter has shown how this may partly be explained by the physical changes which lead in old age to the weakening of the memory; or perhaps we should rather say that in the following passage his remarks respecting loss of memory serve to illustrate the loss of brain power generally, and especially of the power of forming new ideas, in old age. "The impairment of the memory in old age," he says, "commonly shows itself in regard to new impressions; those of the earlier period of life not only remaining in full distinctness, but even it would seem increasing in vividness, from the fact that the eye is not distracted from attending to them by the continued influx of impressions produced by passing events. The extraordinary persistence of early impressions, when the mind seems almost to have ceased to register new ones, is in remarkable accordance with a law of nutrition I have formerly referred to. It is when the brain is growing that the direction of its structure can be most strongly and persistently" (query lastingly?) "given to it. Thus the habits of thought come to be formed, and those nerve-tracks laid down which (as the physiologist believes) constitute the mechanism of association, by the time that the brain has reached its maturity; and the nutrition of the organ continues to keep up the same mechanism in accordance with the demands upon its activity, so long as it is being called into use. Further, during the entire period of vigorous manhood, the brain, like the muscles, may be taking on some additional growth, either as a whole or in special parts; new tissue being developed and kept up by the nutritive process, in accordance with the modes of action to which the organ is trained. And in this manner a store of 'impressions' or 'traces' is accumulated, which may be brought within the 'sphere of consciousness' whenever the right suggesting-strings are touched. But as the nutritive activity diminishes, the 'waste' becomes more rapid than the renovation; and it would seem that while (to use a commercial analogy) the 'old-established houses' keep their ground, those later firms, whose basis is less secure, are the first to crumble away—the nutritive activity, which yet suffices to maintain the original structure, not being capable of keeping the subsequent additions to it in

working order. This earlier degeneration of later formed structures is a general fact perfectly familiar to the physiologist."

One of the most remarkable features of mental development, characteristic, according to circumstances, of mental growth and of mental decay, is the change of taste for mental food of various kinds. Everyone must be conscious of the fact that books, and the subjects of thought, lose the interest they once had, making way for others of a different nature. The favourite author whose words we read and re-read with continually fresh enjoyment in youth, appears dull and uninteresting as the mind grows, and becomes unendurable in advanced years. And this is not merely the effect of familiarity. I knew one who was never tired of reading the works of a famous modern novelist until the age of twenty-five or thereabouts, when it chanced that he was placed in circumstances which caused novel-reading to be an unfrequent occupation, and in point of fact certain works of this author were not opened by him for ten or twelve years. He supposed, when at the end of that time he took up one of these works, that he should find even more than the pleasure he formerly had in reading it, since the story would now have something of novelty for him; and he had once thoroughly enjoyed reading it, even when he almost knew the work by heart. But he no longer found the work in the least interesting; the humour seemed forced, the pathos affected, the eloquence false; in short, he had lost his taste for it. In the meantime, the works of another equally famous humourist had acquired a new value in his estimation.* They had formerly seemed rather heavy reading; now, every sentence gave enjoyment. They appeared now as books not to be merely tasted or swallowed, but, as Bacon hath it, "to be chewed and digested." The change here described indicated (in accordance at least with the accepted estimates of the novelist and humourist in question) an increase of mental power. But a distaste for particular writings may imply the decay of mental power. And also, more generally, a tendency to disparagement is a very common indication of advancing mental age. "The old brain," says Wendell Holmes, "thinks the world grows worse, as the old retina thinks the eyes of needles and the fractions in the printed sales of stocks grow smaller."

Another singular effect of advancing years is shown by the tendency to repetition. It is worthy of notice that this peculiar mental phenomenon has been clearly associated with physical deterioration of the substance of the brain, because it may be brought about by a blow or by disease. Wendell Holmes, speaking of this peculiarity, remarks, "I have known an aged person repeat the same question five, six, or seven times, during the same brief visit. Everybody knows the archbishop's flavour of apoplexy in the memory as in the other mental powers. I was once asked to see to a woman who had just been injured in the street. On coming to herself, 'Where am I? What has happened?' she asked. 'Knocked down by a horse, ma'am; stunned a little; that is all.' A pause, while one, with moderate haste, might count a hundred; and then again, 'Where am I? What has happened?' 'Knocked down by a horse, ma'am; stunned a little; that is all.' (Mr. Holmes appears to have sympathised with the patient's condition.) Another pause, and the same question again; and so on during the whole time I was by her. The same tendency to repeat a question indefinitely has been observed in returning members of those worshipping assemblies whose favourite hymn is, 'We won't go home till morning.' Is memory, then," he proceeds, "a material record? Is the brain, like the rock of the Sinaitic Valley, written all over with inscriptions left by the long caravans of thought, as they have passed year after year through its mysterious recesses? When we see a distant railway-train sliding by us in the same line, day after day, we infer the existence of a track which guides it. So, when some dear old friend begins that story we remember so well, switching off at the accustomed point of digression; coming to a dead stop at the puzzling question of chronology; off the track on the matter of its being first or second cousin of somebody's aunt; set on it again by the patient, listening wife, who knows it all as she knows her well-worn wedding ring—how can we doubt that there is a track laid down for the story in some permanent disposition of the thinking-marrow?"

We seem to recognise here a process of change in the brain corresponding to that which takes place in the body with advancing years—the induration of its substance, so that it loses flexibility, and thus while readily accomplishing accustomed work, is not readily adapted for new work. Our old proverb, "You can't teach an old dog new tricks," indicates coarsely enough, but justly, the peculiarity, as well mental as bodily, to which I refer. There is not a loss of power, but a loss of elasticity. We see aged men working well in the routine work to which they have become accustomed, but failing where there is occasion for change either of method or of opinion. Again, one recognises this peculiarity in the scientific worker, whence perhaps we may regard it as a fortunate circumstance that the tendency of the aged mind accords with its faculties, so that old men do not readily undertake new work.

(To be continued.)

* Probably the best means of testing the development of one's own mind consists in comparing the estimate formed, at different times, of the value of some standard work. Of course, different classes of writing should be employed to test different faculties of the mind. A good general test may be found in Shakespeare's plays, and perhaps still better in some of Shakespeare's sonnets. As the mind grows, its power of appreciating Shakespeare increases; and the great advantage of this particular test is that the mind cannot overgrow it. It is like the standard by which the sergeant measures recruits, which will measure men of all heights, not failing even when giants are brought to be measured by it.

PERIODICAL COMETS DUE IN 1890.

By W. T. Lynn, B.A., F.R.A.S.

Of the four periodical comets which are expected to return next year, two are of well-established periods, and have been seen on several occasions; the other two have each been observed at one return, with a probability that it was seen on an occasion several revolutions earlier.

Brorsen's was discovered at Kiel on the 26th of February 1846. Its period is about five and a half years, and it was subsequently observed at returns in 1857, 1868, 1873, and 1879. Another will be due early in 1890.

D'Arrest's was discovered at Leipzig on the 27th of June 1851, it has a period of six and a half years, and was observed in 1857–8, in 1870, and in 1877. It escaped observation in the winter of 1883, but another return will be due next summer.

M. Coggia discovered a small comet at Marseilles on the 10th November 1873. The investigation of Prof. Weiss made it probable that this was identical with one detected by Pons on 23rd February 1818, but, though its period is probably about five and a half years in duration, it has not been seen since 1873. Returns, if that be the true period, were due in 1879 and 1884; and another will be expected to take place early next year.

Mr. Denning discovered a comet at Bristol on the 4th of October 1881. This has been thought to be identical with a comet found by M. Blanpain on the 28th of November 1819. On this point M. Schulhof remarks (*Ast. Nachr.* No. 2401), "La comète appartient incontestablement au groupe* toujours croissant des comètes périodiques dont la durée de révolution varie entre 5 et 7 ans. Son identité avec la comète 1819 iv, pour laquelle Encke avait trouvé une révolution de 4·8 ans, ne peut pas être décidée. Malgré la ressemblance générale des deux orbites, que Mr. Chandler a reconnue le premier, les éléments sont trop différents pour que nous puissions nous prononcer en faveur de leur identité, avant d'avoir suffisamment fixé les éléments de la nouvelle comète, et recherché si, entre 1819 et 1881, elle a pu subir de la part de Jupiter des perturbations aussi considérables."

The last determination, I believe, of the orbit of Denning's comet is that of Mr. W. E. Plummer, published in No. 25 of *Copernicus* (vol. iii. p. 1), which makes its period 3,235 days, or about 8·8 years, so that as the perihelion passage in 1881 took place on the 13th of September, the next will be due soon after Midsummer 1890.

Prof. Winnecke suggested that Denning's comet might be identical with one seen (once only) by Goldschmidt on the 16th of May 1855, and which was also thought to have been identical with the lost comet of De Vico. But as Goldschmidt could only obtain one approximate position, neither of these conjectures admits of proof.

* The group connected with the planet Jupiter.

R. A. PROCTOR MEMORIAL FUND.

Readers of Knowledge will, no doubt, have noticed an announcement in many of the daily papers stating that the monetary affairs of the late Mr. Proctor have now been wound up by his administrator, and that the total sum available as provision for his widow and the seven children (four of whom are daughters, and one a little boy a permanent invalid from hip disease) is under £2,000. To the small income which this will produce there is to be added £100 per annum from the Civil List, which is, however, granted only during Mrs. Proctor's life.

The £2,000 above referred to as the value of the residue after the settlement of all debts, some of which were waived, has been produced by the sale of Mr. Proctor's copyrights. Mrs. Proctor and the eldest daughter have, under a satisfactory arrangement with Messrs. Longmans, retained a small interest in the works now in Messrs. Longmans' hands, including the *Old and New Astronomy*, which will shortly be completed. But the value of the interest retained (calculated on the basis of the sum given for the remainder of these copyrights by Messrs. Longmans) is included in the £2,000, as is also the money received for all the other copyrights, which were purchased on liberal terms either by Messrs. Chatto & Windus, or by Messrs. W. H. Allen & Co.

The money given immediately after the death of the late Mr. Proctor by the Royal Literary Fund, and the proceeds of five lectures given by Mr. W. Lant Carpenter, as well as gifts from other friends, have enabled the family, who, owing to the suddenness of Mr. Proctor's death, were absolutely without resources, to weather through the first year. But these funds have now been exhausted, and a committee is in course of formation which the many friends of Mr. Proctor are invited to join. Subscriptions to the R. A. Proctor Memorial Fund, and communications will be received by Mr. E. G. Mullins, Manager of the City Bank, Bond Street Branch.

Since the date of the announcement in the daily papers the following subscriptions have been received :—

	£	s.	d.
Wm. James Adams, Esq.	0	10	6
"E.A."	2	0	0
Mrs. Barrett	2	0	0
"J. A. B."...	1	0	0
Andrew Chatto, Esq.	5	0	0
H. P. Curtiss, Esq.	5	0	0
W. Henry Domville, Esq....	10	0	0
"W. D."	2	2	0
"A Friend	1	0	0
Professor Grant	2	2	0
Lord Grimthorpe	20	0	0
D. Hodgson, Esq.	1	0	0
Edmund Johnson, Esq.	1	1	0
Messrs. Longmans, Green, & Co.... ...	20	0	0
J. Mott Maidlow, Esq.	3	3	0
Miss Martin	2	0	0
G. H. Mellor, Esq.	0	10	0
R. Hay Murray, Esq.	5	0	0
"Planetoids"	0	10	6
T. Shaw Petty, Esq.	10	10	0
Oscar Rohde, Esq.	3	3	0
T. C. Sandars, Esq.	5	0	0
Wm. Schooling, Esq.	2	2	0
F. Stevens, Esq.	1	1	0
Col. N. G. Sturt	5	0	0
Mrs. Stowe...	0	5	0
Walter Weblyn, Esq.	1	1	0
Philip Williams, Esq.	1	0	0
	£113	1	0

And others promised.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

EXTRACT FROM A LETTER FROM PROF. C. A. YOUNG REFERRING TO REVIEW OF THE "GENERAL ASTRONOMY" IN THE NOVEMBER NUMBER.

To the Editor of Knowledge.

". . . . There is just one thing in the critique which I want to ask you to correct, because it does an injustice to others. My *printers* were to blame for only a very small proportion of the errata that occurred in the book. For most of them I am myself responsible. The preparation of the last half of the book (after p. 200) and the proofreading of the whole was done by me in a time of great distress (owing to my son's illness); and though I do not plead this circumstance as an *excuse*, it is an *explanation*, at least in part. I really wish you would take occasion to say editorially that 'whatever blame may attach to the numerous errata in Prof. Young's *General Astronomy* belongs almost entirely to himself, and not to the printers,' or something to that effect. . . . "C. A. Young."

[Instead of making the announcement editorially, I prefer to let Prof. Young's letter speak for itself. It shows in a characteristic manner Prof. Young's extreme anxiety

not to do an injustice to anyone. The son to whom he refers received last year a powerful electric shock through his body from hand to hand, from which he still lies an almost helpless wreck, unable to rise, and hardly able to lift his arms. This is the illness to which the letter refers. We are now so widely welcoming the Dangerous Demon of Electricity, that the accident to this promising young electrician (whom I remember as an Eclipse observer in Colorado in 1878) cannot be too widely used as a warning.

[Our last number was not a fortunate one in which to allude to the mistakes of American printers. It contained a good many printers' errors—probably due to the fact that it was the first number printed by fresh printers.—A. C. Ranyard.]

COMPARISON OF PHOTOGRAPHIC EFFICIENCY OF TELESCOPES.

To the Editor of Knowledge.

Dear Sir,—Visually, I presume there is no difference of opinion that the faintness of a star which may be seen with a telescope depends almost entirely on the square of the diameter of the lens, and is independent of the focus. If the seeing is very bad, of course the large glass labours under a slight disadvantage; but we are assuming reasonably good astronomical conditions. In looking for faint stars, we would naturally use as low a power as the telescope would bear.

Photographically, diffraction has very little to do with determining the size of the image of a star. The size depends chiefly on the steadiness of the air, the accuracy of the following, and the correctness of the lens. The formulæ expressing it must therefore be only approximate and entirely empirical. It has been found that under favourable conditions at Cambridge with a 3-inch camera lens, the images of the fainter stars were ·035 mm. in diameter. With an 8-inch camera they were ·028 mm., and with a 13-inch telescope ·047 mm. The two latter instruments were finished by the Clarks. If the same had been true of the former, the images would undoubtedly have been smaller.

If faint star images were always of the same size, the faintness of a star which we might detect by photography would be inversely proportional to the square of the aperture of the instrument and independent of its focus—the same as for visual telescopes. As stated in my former communication (in connection with the formulæ then given), this is perhaps hardly fair to the larger instrument, as an increase of focus gives slightly larger images, and a modification in the formulæ is therefore introduced.

In Cambridge, under favourable circumstances, with the 13-inch lens, the diameter of a photographic star image is about 2″.

As regards the Orion nebula, I have been more delayed than I had expected, as I find on close examination that our negatives show much more detail than I had at first supposed. This involves a good deal more work, but I am hoping to have my results in final shape in the course of a few weeks more.

Very truly yours,

W. H. Pickering.

Harvard College Observatory, Cambridge, U.S.A.

[The diameter of 2″ mentioned by Prof. W. H. Pickering is very small, and would seem to show that at Harvard the atmosphere is occasionally very tranquil. With two instruments of equal diameter, one double the focal length of the other, we should expect the same atmospheric inequalities to cause double the swing in the longer focussed instrument, that is, the luminous image of a star would travel over an area four times as great on a photographic plate in the focus of the longer instrument than on one in the focus of the shorter instrument. But the disc and rings are of double the diameter, and, area for area, of one fourth the intensity in the longer focussed instrument. The actual difference in the diameter of the initial patch of photographic action needs to be determined by experiment, before photographs taken with different instruments can be used for comparing the tranquillity of the atmosphere at two stations.—A. C. R.]

To the Editor of Knowledge.

Dear Sir,—A fireball of remarkable brilliancy was observed here on November 4th, at 7h. 55m. G.M.T. It appeared to the north and below the pole star. That portion of the heavens was considerably obscured by cumulus clouds, and the passage of the fireball was shown by a series of flashes as it passed the intervening clearer spaces, which might have been taken for flashes of lightning. So far as could be made out, a line drawn from β Draconis to Castor would roughly indicate its path, and it moved from a considerable altitude obliquely downwards toward the N.E. horizon.

When first seen it equalled Venus at greatest brilliancy, and rapidly increased in size and brightness. When below the pole it burst with an intensely brilliant flash, which illuminated the whole northern region, but instead of being dissipated as usual, a large portion, fully equal to Jupiter in brightness, and much brighter than a first magnitude star, continued its course towards the N.E. horizon. The moon, about eleven days old, was shining brilliantly at the time. The duration was not more than six or seven seconds, and the light was decidedly blue.

See also *Nature*, Nov. 14, p. 32; also *Nature*, Nov. 21, p. 60, which must all refer to the same, and may interest you.—Yours truly,

C. E. Peek.

Rousdon Observatory, Lyme.

To the Editor of Knowledge.

Sir,—Possibly the following may now be of some interest.

Some years ago I was in a small brick house in the Kew Road, Richmond. In a room on the ground floor an ordinary "register stove" fire-grate, filled with coal, was covered from the back to the hearth with a piece of newspaper; over the lower two-thirds of this was placed a sheet of cut tissue paper, of a bright green colour, and on the upper two-thirds, over all, was a sheet of pink tissue paper. Thus about one-half of the green paper was placed between one-half of the pink paper and the newspaper, and in contact with both.

One morning I found that in the night the whole of the green paper, except a few scraps of the corners, had been reduced to ash; but the pink paper and the newspaper were uninjured, with the exception of a few small burnt holes.

The grate was in an outside wall, and on the outside of the wall was an iron rainwater pipe from the roof, cut off a foot or more from the ground.

I was careful to ascertain at the time that no one in the house could by accident or otherwise have done it. Any kind of trick was quite unimaginable.

I can only suppose that the cause was a slight electric discharge.

Yours faithfully.

128, Mount Street, W. T. S. Petty.

To the Editor of Knowledge.

Dear Sir,—In the series of beautiful photographs of our satellite you have favoured your readers with in the October number, a striking feature seems to me to be clearly brought out, viz. the elevated region to the north-westward of Tycho; this is much beyond the projection of a segment of a sphere, corresponding to the moon's limb.

Is not this an indication of increased convexity towards the earth—a displacement of the moon's centre of gravity drawn out by the earth's attraction, earthward—which has resulted ultimately in retarding our satellite's axial rotation?

I merely offer this as a confirmation by the photographs of a theory previously upheld.

Yours truly,
W. Westgarth, jun.

[According to theory, the earth's tidal action on the moon would only cause the lunar diameter directed towards the earth to be about 250 feet longer than the diameter at right angles to it. Such a difference is far too small to measure with the largest telescopes, even if the two diameters were at right angles to the line of sight. Mr. Westgarth must not rely on measures made upon pictures printed upon damped paper, which may have been considerably stretched in lifting from the printing block.—A. C. R.]

THE STRIKE, IN ITS RELATION TO HEALTH AND LIFE.

By Alex. B. MacDowall, M.A.

London was lately the scene of one of the greatest social conflicts of modern times. For some five weeks the din of battle resounded in our ears. The results of that fight are undoubtedly immense and far reaching, and they are not yet by any means fully manifest. We shall not here attempt a wide survey of the new situation, nor a resuscitation of the dry bones of controversy. Our scientific object is merely to inquire how the health and life of London have fared in the course of the unusual experience of this remarkable time. We shall confine our attention to the three months, July, August, and September. The Dockers' strike began about the middle of August, and ended about the middle of September.

Reflecting how large a portion of the community was involved; how the copious stream of wages to something like 100,000 workers was abruptly stopped; how the means of sustenance had to be found from new sources for about 250,000 persons of all ages, a large proportion of whom live continually on the brink of destitution even in prosperous times: one would be inclined to think, *a priori*, that disease and death would appear with a great accession of force.

Yet (dealing with the London of the Registrar-General), if we look at the first two diagrams here presented, showing, first, the deaths week by week (continuous curve), as compared with the corrected average* (dotted line curve), and the deaths of persons at different ages; then, the deaths from various kinds of disease, and other causes, also compared with the averages; we seem to look in vain for anything of the nature of "cataclysm."

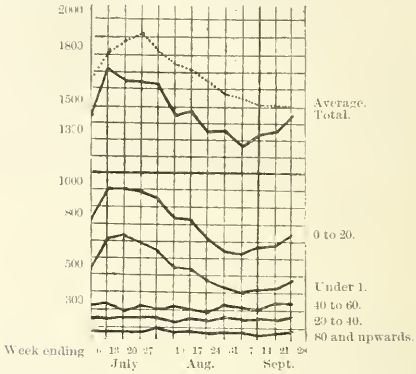


Diagram 1.—Weekly Deaths in London, July-September, 1889

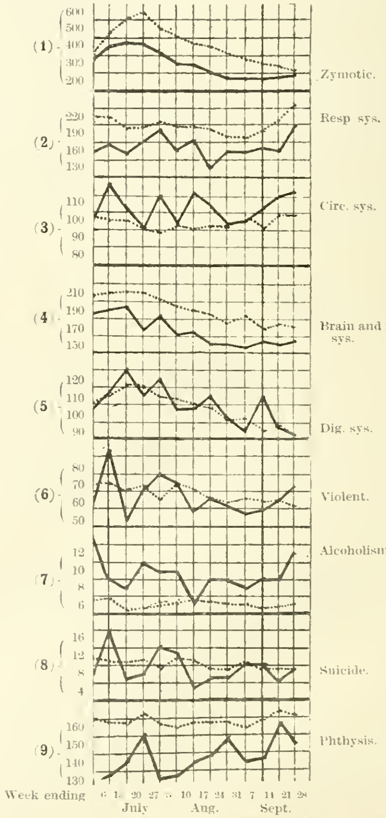


Diagram 2.—Deaths from Various Causes (London).

Our second diagram, we may point out, is really a ver-

* By "corrected average" is meant the average weekly deaths for the ten years 1879–88, raised by 9·046 per cent. for increase of population.

tical series of smaller ones for different causes of death,* the scale varying according to convenience. The curves are made out from the official *Weekly Return*.

The death-rate, to begin with, has been throughout below the average. It certainly shows an increase (not very great) towards the average, from Sept. 7th, and one finds in a few of the disease curves (circulatory system, respiratory system, zymotic, violent, &c.) a rise about the same time, accounting for this increase. But, after all, the relation of those curves to the average (dotted line) curves remains in general good. None of the curves show any great excess over the average, and in most cases the total numbers after the commencement of the strike are under the total of the averages for the same time. We need not dwell much on details.

Of zymotic diseases, diphtheria is the only one that shows a continuous excess of deaths during those three months, and this is not, apparently, connected with the strike. The others show a mortality almost uniformly under the average.

The deaths from diseases of the circulatory system (heart disease, &c.), seem also to have been mostly in excess, but not more after the strike commenced than before it.

We give a curve of deaths from alcoholism (*i.e. delirium tremens*, &c.) The fact that the deaths assigned to this cause have been, not only in those three months, but throughout this year, nearly always in excess of the averages, might be worth the attention of those who are given to very glowing representations of our national progress in temperance (though we must avoid putting too great a strain on these figures). There is no evidence here of an increase of drunkenness during the strike. The drinking, indeed, was no doubt greatly diminished.

Perhaps we might expect an increase of suicides in such a time of pinch and anxiety. But the suicide-curve does not seem to be materially affected. Suicides are classed in the Returns with deaths from accident; homicides and execution under the head of violent deaths; and we may further note that there were nearly twice as many cases of homicide in the period before August 10 as in the longer period after it (17 as against 8). The increase in violent deaths from September 7 appears to have been chiefly in the section of "accidental deaths."

Is it merely a coincidence, or is it more, that directly after the two weeks ending July 13 and August 7, which show relative maxima in the deaths from alcoholism, come two weeks which show corresponding maxima in the number of suicides?

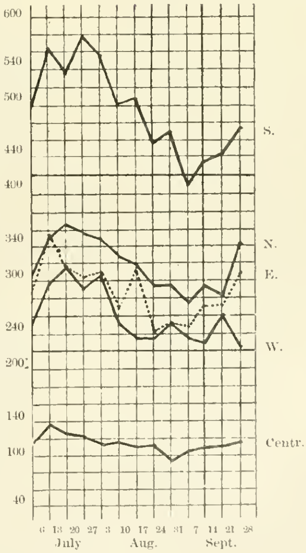


Diagram 3.—Deaths in Districts.

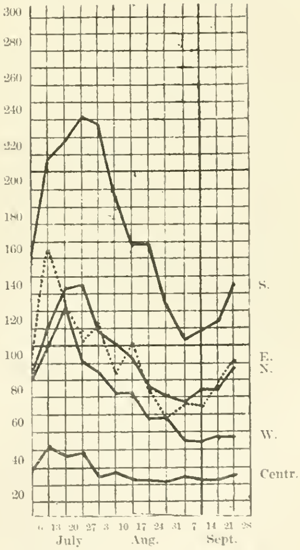


Diagram 4.—Infant Deaths in Districts.

We find, then, on the whole, that the influence of the strike is not, thus far, very apparent. But, remembering that a population of two or three hundred thousand is but a fraction of the whole, it would be well if we could get facts bearing more closely on this portion. This we are enabled to do by the records of deaths in different districts of London—North, South, East, West, and Central. We show these in our third diagram; and as the East and West districts have approximately equal populations (the former had 692,738 in 1881, and the latter 669,633; and the West has probably grown more than the East since that date), we may with advantage specially compare these two, the one being closely affected by the strike, the other not. The fourth diagram shows the infant deaths in the same districts.

There is something of a divergence of those two curves (in Diag. 3) about the end of August. The rise then beginning in the East curve, as also that in the South somewhat later, may be partly connected with the strike. But it will be noticed that there is a general rise in other districts, such as the North and the Central, on which the strike can have had little or no influence; so that some more general cause or causes seem to be indicated.

If the result here again seems to be negative, we must bear in mind the limits of the case presented. Thus, *e.g.* it might very well be that the undoubted privations endured by many during the strike issued in the formation of a soil very favourable to the seeds of disease. The results in such a case might appear considerably later and be spread over a long time. Moreover, we have been dealing only with cases of illness which ended *fatally* in the period considered.

On the other hand, we may recall the very favourable conditions of the strike—the splendid weather throughout, the extraordinary liberality of sympathisers (especially in Australia), the order in general maintained, the skill in organising commissariat, the credit given by tradespeople, &c. To not a few dockers it was probably a case of holiday in London, with regular food, and, in some instances, wholesome restriction of expenditure; and the personal and family deterioration, through squandering of wages in the public-house, must have been much reduced.

In reviewing the facts, it is evident that a great social revolution has taken place with vastly less derangement of the body-politic, in matters here considered, than would have been the case fifty or a hundred years ago.

* "Zymotic disease" here includes small-pox, measles, scarlet fever, diphtheria, whooping-cough, typhus, enteric fever, simple continued fever, diarrhœa and dysentery, and cholera. The chief diseases of the respiratory system are bronchitis and pneumonia; of the brain and nervous system, apoplexy and convulsions; of the digestive system, liver disease, dentition, enteritis, and peritonitis; of the circulatory system, heart disease, &c.

THE FACE OF THE SKY FOR DECEMBER.

By Herbert Sadler, F.R.A.S.

Both sunspots and faculæ continue to increase slowly in number. There will be a total eclipse of the sun on the morning of December 22, but it will not be visible in Europe. Conveniently observable minima of Algol take place on the 11th at 11h. 10m. p.m., on the 14th at 8h. 6m. p.m., and on the 17th at 4h. 49m. p.m. Mercury comes into superior conjunction with the sun at midnight on the 7th, and is invisible throughout the month. Venus is a morning star, but is getting fainter daily. On the 1st she rises at 5h. 53m. a.m., with a southern declination of 16° 45′, and an apparent diameter of $10\frac{1}{2}''$. On the 31st she rises at 7h. 18m. a.m., 50 minutes before sunrise, with a southern declination of 23° 21′, and an apparent diameter of 10″. At 7 a.m. on the morning of the 10th she will be $6\frac{1}{2}'$ due south of β Scorpionis, the two forming a close naked-eye pair. She does not approach any other conspicuous star very nearly. During the month she passes from Libra through portions of Scorpio and Ophiuchus into Sagittarius. Mars is a morning star, in Virgo throughout the month, but his diameter does not exceed $6\frac{1}{2}''$, and, though increasing in brightness, the ordinary observer will make out nothing but a small gibbous red disc. On the 1st he rises at 2h. 20m. a.m., with a southern declination of $3\frac{1}{2}°$, and on the 31st at 2h. 0m. a.m., with a southern declination of 10°. He is about 1° north of Uranus on the 24th and 25th. Jupiter has left us for the season. Saturn is now getting into a favourable position for observation, rising on the 1st at 10h. 41m. p.m., having a northern declination of $11\frac{1}{2}°$, and an apparent diameter of $17\frac{3}{4}''$ (the major axis of the ring being $41\frac{1}{2}''$ and the minor $5\frac{3}{4}''$ in diameter). On the 31st he rises at 8h. 37m. p.m., with a northern declination of 11° 39′ and an apparent diameter of nearly 19″ (the major axis of the ring being $43\frac{1}{2}''$ and the minor $6\frac{1}{4}''$ in diameter). He is in Leo, to the east of Regulus, and is practically stationary throughout the month. On the evening of the 2nd Titan will be about 25″ *n.* of Saturn, and on the 10th about 26″ *s.* a little *f.* At 10h. 30m. on the 13th Iapetus will be 22″ due south. On the 18th Titan is about 28″ *n.p.*, and on the 26th about 28″ *s.f.* the planet. As Uranus does not rise till 1h. 40m. a.m. on the last day of the month, he is practically invisible to the amateur. Neptune is very favourably situated for observation, rising on the 31st at 3h. 32m. p.m., with a northern declination of 19° 5′, and an apparent diameter of $2\frac{3}{4}''$. On the 31st he rises at 1h. 32m. p.m. A map of the small stars near his path will be found in the *English Mechanic* for November 15th. He is in Taurus, and on the evening of the 23rd will be 19′ due south of the 6th magnitude star 43 Tauri. December is a fairly favourable month for shooting stars, the chief shower being that of the Geminids on December 9-12, the radiant point being in R.A. V 11h. 0m. and declination 32°, rising about 4h. 10m. p.m., and setting at 1h. 40m. a.m. The moon is full at 9h. 52m. a.m. on the 7th, enters her last quarter at 2h. 58m. p.m. on the 15th, is new at 0h. 52m. p.m. on the 22nd, and enters her first quarter at 5h. 16m. a.m. on the 29th. On the 8th at 5h. 16m. p.m. the $3\frac{1}{2}$ magnitude star η Geminorum will disappear at an angle of 56° from the vertex, and reappear at an angle of 241° at 5h. 1m. p.m. At 9h. 34m. p.m. the same evening the 3rd magnitude star μ Geminorum will make a near approach to the lunar limb at an angle of 330° from the vertex. At 4h. 55m. p.m. on the 9th the $6\frac{1}{2}$ magnitude star 44 Geminorum will disappear at an angle of 27° from the vertex, the moon being below the horizon of Greenwich at the time, and will reappear at 5h. 34m. p.m., the star being on the horizon at the time, at an angle of 282°. At 2h. 10m. a.m. on the 10th the 6th magnitude star 58 Geminorum will disappear at an angle of 80°, and will reappear at 3h. 33m. a.m. at an angle of 299° from the vertex. At 7h. 56m. p.m. on the 10th the $6\frac{1}{2}$ magnitude star 7 Cancri will disappear at an angle of 70° from the vertex, and reappear at 8h. 51m. p.m. at an angle of 211° from the vertex. At 11h. 35m. p.m. on the 15th the $6\frac{1}{2}$ magnitude star B.A.C. 4101 will disappear at an angle of 40° from the vertex, and reappear at 0h. 31m. a.m. on the 16th at an angle of 202° from the vertex. The same morning at 4h. 57m. a.m. the 5th magnitude star c Virginis will make a near approach at an angle of 130°. At 5h. 5m. p.m. on the 31st the 6th magnitude star B.A.C. 830 will disappear at an angle of 123°, and reappear at 6h. 3m. p.m. at an angle of 240° from the vertex.

Whist Column.

By W. Montagu Gattie.

INFERENCE FROM AN ADVERSE DISCARD.

The following hand, which occurred a few years ago in actual play, and was published at the time in the *Field*, furnishes an excellent illustration of the information that may be gained from an opponent's discard. The play of the hand is in other respects very brilliant, and quite worthy of the reputation of the late Mr. F. H. Lewis, who held A's cards, and in memory of whom we now reproduce the game. Mr. Lewis was a distinguished and enthusiastic whist-player, and an occasional correspondent of this paper. He will long be missed in London whist circles.

Hand No. 7.

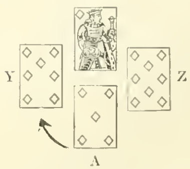
A's Hand.

Score—One All. Z turns up the seven of hearts.

Note.—A and B are partners against Y and Z. A has the first lead; Z is the dealer. The card of the leader to each trick is indicated by an arrow.

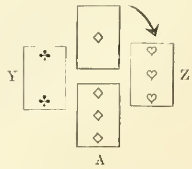
The notes appended to the tricks are supposed to be made during the play by the player whose hand is exposed. The subsequent remarks relate to the play generally.

Trick 1.



Tricks—AB, 1; YZ, 0.

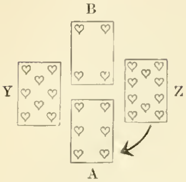
Trick 2.



Tricks—AB, 1; YZ, 1.

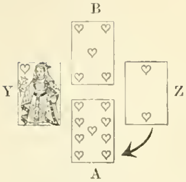
Note.—*Trick* 2.—Y is void of diamonds, and his discard of a club shows that his strong suit is spades.

Trick 3.



Tricks—AB, 1; YZ, 2.

Trick 4.

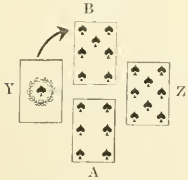


Tricks—AB, 1; YZ, 3.

Notes.—*Trick* 3.—Y has either no more trumps, or the queen of hearts single.

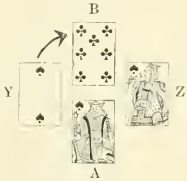
Trick 4.—Z's lead shows that the queen is with Y; but A, nevertheless, passes the trick in order that Y, who has shown strength in spades, may lead them up to king, knave, guarded. The remaining trumps are now marked in Z's hand.

Trick 5.



Tricks—AB. 1; YZ, 4.

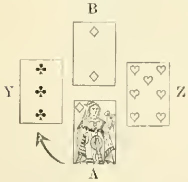
Trick 6.



Tricks—AB, 2; YZ, 4.

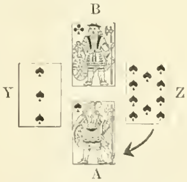
Note.—*Trick* 6.—A can now count the cards as follows: B has four diamonds, and three clubs all higher than the seven; Z has three trumps; and Y and Z have five spades between them, of which three at least are with Y.

Trick 7.



Tricks—AB, 2; YZ, 5.

Trick 8.

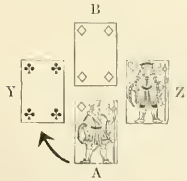


Tricks—AB, 3; YZ, 5.

Notes. *Trick* 7.—If A now leads out his ace of trumps, and if it should turn out (as is actually the case) that Z has four spades and so can put his partner in once more after drawing the knave, it is clear that YZ will make two tricks in spades and two trumps, and will consequently win the game. A, therefore, with admirable judgment, refuses to draw a trump, and prefers to continue the diamond force.

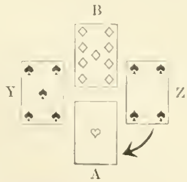
Trick 8.—B's discard determines A to continue his forcing tactics, and to reserve his ace for ruffing in the event of Z's having a fourth spade.

Trick 9.



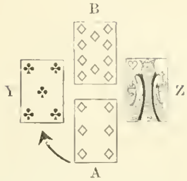
Tricks—AB, 3; YZ, 6.

Trick 10.



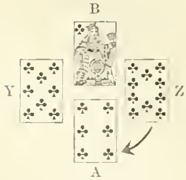
Tricks—AB, 4; YZ. 6.

Trick 11.



Tricks—AB, 4; YZ. 7.

Trick 12.



Tricks—AB, 5; YZ. 7.

Trick 13.—B makes the ace of clubs, and AB save the Game.

A's Hand.	B's Hand.
H.—Ace, 9, 6.	H.—5, 4.
S.—Kg, Kn, 6.	S.—7.
D.—Qn, Kn, 6, 5, 3.	D.—Ace, Kg, 10, 9, 4, 2.
C.—9, 6.	C.—Ace, Qn, Kn, 7.

Y's Hand.	Z's Hand.
H.—Qn, 8.	H.—Kg, Kn, 10, 7, 3, 2.
S.—Ace, 9, 5, 3, 2.	S.—Qn, 10, 8, 4.
D.—7.	D.—8.
C.—8, 5, 4, 3, 2.	C.—Kg, 10.

Remarks.—*Trick* 2.—As A must have at least three diamonds remaining, B, who himself has five, knows that one of the adversaries will fall short on the second round. His return of the ace is, however, quite defensible, seeing that he is very weak in trumps, although many players would have preferred to open the club suit. This latter course, as it happens, would have lost the game.

Trick 5.—Y plays badly in opening with his ace, especially as he has no card of re-entry. The rule that ace should be led from a five-suit does not apply when trumps are out. Y's proper play would be to lead his penultimate spade, and to finesse on the return of the suit. Z rightly puts on the eight instead of the four, so as to avoid blocking his partner.

Trick 6.—The ten of spades would have been rather better play on Z's part than the queen, since the king is marked in A's hand. It is worth noticing that a case here arises in which an American lead would be disadvantageous to the leader. If Y had continued with the three of spades, A could have placed five originally in his hand, and therefore four originally in Z's hand, and would have had much less difficulty in discovering the only way in which the game could be saved.

Trick 8. B very properly discards his knave of clubs instead of a diamond, thus affording a valuable indication of the quality of his remaining clubs.

Elementary Explanation of the Play.

Trick 1.—A opens his longest suit.

Trick 2.—B follows the ordinary rule in returning the ace at once. Y discards from his weakest suit. A can now count four diamonds in his partner's hand.

Trick 3.—Z leads from king, knave, ten; but, as the same card would be led from king, queen, knave, ten, A cannot tell, until Z leads again, whether the queen is with Z or with Y. But, as A himself has the nine, and king, knave, are marked with Z, Y's eight shows that he has the queen single or no more.

Trick 4.—Guided by Y's discard at trick 2, A determines to let him have the lead, so that he may open spades up to king, knave, guarded. The remaining trumps are marked with Z, for he turned up the seven, and his lead of the ten shows that he has knave and king.

Trick 5.—Ordinarily speaking, Y's lead of ace from a five suit is correct; but here he gives up the only card

upon which he can depend for regaining the lead and bringing in his small spades.

Tricks 6 to 12. The whole point of A's play is to prevent Z from assisting Y to bring in the long spades. A's knave of spades blocks the third round (trick 8), and the ace of trumps is retained to block the fourth round in case Z should be provided with a fourth spade. This is a very interesting example of the importance, under certain circumstances, of abstaining from drawing a losing trump. After trick 6 B still holds four diamonds, and as he is void of trumps and spades, his other three cards must be clubs. His discard of the knave at trick 8 shows A that the two remaining clubs are honours, and that it is desirable to throw the lead into Z's hand, so that he may ultimately be forced to lead clubs up to B.

Chess Column.

By I. GUNSBERG (MEPHISTO).

[Contributions of general interest to chess-players are invited. Mr. Gunsberg will be pleased to give his opinion on any matter submitted for his decision.]

END-GAMES.*

When in 1851 Horwitz and Kling produced their book on End-games, they were well in advance of the time. Their interesting collection has held the field for many years, and is still unique in some respects, as many of the so-called "Studies" may be more accurately described as Problem studies, or Compositions. The literary tendency at the present time is, however, I regret to say, too much towards utilitarianism, and therefore the new work by Professor Berger, arranged systematically, on an academic plan of progressive study, may perhaps be considered a work of greater scope and utility from a student's point of view. But then we are not all students, we do not all of us burn the midnight oil in order to acquire the benefit of the latest laborious essay on the Ending of Rook against Rook and Bishop, we play Chess for pleasure and recreation; and although it is only natural that we should have some ambition to increase our stock of learning of our favourite pastime, for the sake of the greater pleasure which we may derive from greater knowledge, yet we should draw the line somewhere, and give preference to those books which combine amusement with instruction. The End-game Studies before us have that happy blend of instruction and amusement which will always please and never fatigue, and I venture to say, for that reason, they will continue to enjoy great popularity among English readers. Annexed are examples of Endings, which will best show the various kinds of studies, both useful and entertaining, contained in the book.

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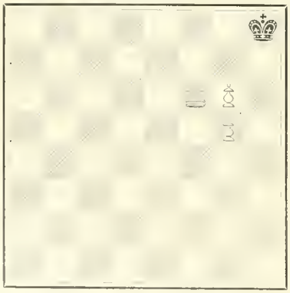

WHITE.

White with the move cannot win, but if Black moves first, White wins.

Solution.

1.	K to Kt sq
2. P to Kt7	K to R2
3. P Queens	K × Q
4. K to Kt6, and win.	

* *Chess Studies and End-Games.* By Horwitz and Kling. Second Edition. (G. Bell & Sons.)

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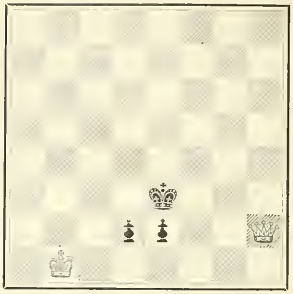

WHITE.

White to move and win.

Solution.

1. Q to R6 (ch)	K to Q6 (best)
2. Q to Q6 (ch)	K to B6
3. Q to B5 (ch)	K to Q6
4. Q to QB2 (ch)	K to K6
5. Q to B3 (ch) and wins.	

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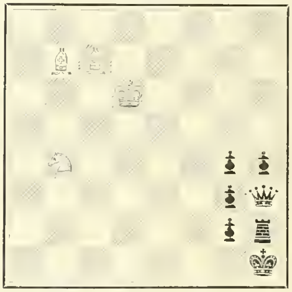

WHITE.

White to move and win.

1. Kt to B2	K to Kt8	8. K to Q2 (ch)	K to R8
2. B to Kt6 (ch)	K to R8	9. Kt to Q4	K to Kt8
3. K to B5	K to Kt8	10. Kt to K6 (ch)	K to R8
4. K to Q5 (ch)	K to R8	11. Kt to B5	K to Kt8
5. K to Q4	K to Kt8	12. Kt to K4	K to R8
6. K to K4 (ch)	K to R8	13. B to B5	P to Kt8 (ch)
7. K to K3	K to Kt8	14. Kt to B2 mate	

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Female Flea (Enlarged about 40 Diameters).

Male Flea (Enlarged about 40 Diameters)

DOMESTIC PESTS: THE COMMON FLEA (*Pulex irritans*).

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AN ILLUSTRATED
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LONDON: JANUARY 1, 1890.

CONTENTS.

THE COMMON FLEA.*—II.

By E. A. BUTLER.

THE digestive apparatus of a flea (Fig. 4) consists of parts very similar in their arrangement and function to those of the cockroach, and therefore needs no detailed description. The œsophagus is a rather short and narrow tube leading into a thick-walled gizzard, which, again, opens by its broader end into a capacious bag, the stomach, big enough to hold a large draught of blood, such as the insect is only too eager to suck in whenever it can get the opportunity. At the junction of the stomach with the intestine are four long, thin, blind tubes, the Malpighian tubules. The hinder end of the intestine expands into an inverted pear-shaped cavity, the rectum, on the walls of which are six oval glands.

The alimentary canal, when gorged with blood, can be rapidly emptied by the insect, and its contents ejected with considerable force, when a new and good supply of food presents itself before the last meal is disposed of. The dark stains on linen, that indicate where fleas have been, consist of their dried excrement, and are composed of the undigested remains of the blood corpuscles contained in the food. Judging from the fact that rooms that have long been unoccupied are sometimes found to be swarming with fleas, it would seem that the perfect insects can subsist for a time without their customary food, although they are rapacious and insatiable enough when it is obtainable. And even under ordinary circumstances their living must not unfrequently be precarious, and their meals most irregular. As is well known, it is not every human being that they regard as fit to supply them with nutriment; some individuals they seem instinctively to avoid, whether by reason of a greater thickness and toughness of skin, or of something distasteful in the blood, or from some other cause, it is impossible to say. That they should prefer a host with a soft and delicate skin is only natural, and is evidenced by their marked partiality for females and young children, though it must not be forgotten that some of this apparent partiality may be due to the extra facilities that are afforded to the parasites, in the case of these sections of the community, by the character of the clothing, the greater looseness of which renders them easier subjects for the fleas to gain access to and therefore to operate upon.

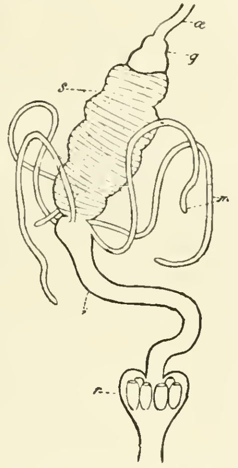


FIG. 4.—DIGESTIVE APPARATUS OF DOG'S FLEA. *œ*, œsophagus; *g*, gizzard: *s*, stomach; *m*, malpighian tubules; *i*, intestine; *r*, rectum. (After Landois.)

In consequence of the compression of the body and the comparative transparency of the skin, many details of internal anatomy may be made out in the living flea, if it be examined under the microscope with good illumination by transmitted light. The tracheæ, or breathing tubes, can thus be very easily traced, even down to many of their finer branches, and the large trunks that traverse the length of the body are especially conspicuous objects; large branches may also be easily seen running down the legs. If the flea is confined so that it can only move slightly, the contraction of the muscles, especially in the coxæ, can be watched without any difficulty, as any little twitchings occur in the legs. A living flea is a very pretty object when viewed with polarised light.

The original photographs from which the enlargements in the accompanying plate were taken were obtained from specimens prepared for the microscope, and therefore completely flattened. In the process of mounting, the thoracic segments unavoidably become slightly dislocated from their natural position; this is especially noticeable in the male. The greater part of the contents of the body also have been dissolved out, in order to increase the transparency of the object, and hence very little of the internal anatomy can, in these specimens, be seen. The most prominent object in this connection is the reproductive apparatus of the male; the bars and coiled threads at the hinder extremity are all parts of these organs, and are really internal in position, though they hardly seem so. The coiled threads are attached to the part of the organ that can be protruded.

We have now to trace the life history of the flea. The eggs are oval, whitish, sticky things, and though, of course, actually minute, are yet rather large in proportion to the size of the insect itself, their longest diameter being about $\frac{1}{40}$th of an inch, and the shortest $\frac{1}{60}$th. So far as the human species is concerned, the eggs appear to be laid, not upon the body or clothes of the host, but amongst

* The plate illustrating this paper has been made from photographic enlargements of a male and female flea prepared for the magic lantern by Messrs. Frederic Newton & Co., Opticians, of No. 3, Fleet Street, E.C.

rugs, mats, and other accumulators of dust and dirt. It is commonly believed that cats and dogs bring fleas into a house, and there is certainly good evidence that at least their own parasites may be introduced in this way. For example, Mr. S. J. McIntire states that, wishing to obtain some eggs of the cat's flea, he placed, late one night, a cloth for his cat to lie upon, and early in the morning inspected it in order to collect any eggs that might have been deposited. On the first night, 62 eggs were obtained, on the second 78, on the third 67, and on the fourth 77, a total of 284 eggs from one cat in the course of four nights! No doubt many of these, if left to themselves, would never have reached maturity; still the number is sufficiently startling, and, unless the animal in question was literally swarming with vermin, seems to indicate on the part of the cat's flea a fecundity considerably in excess of what is usually attributed to the human species, which is said to produce only about a dozen at a laying. Of course it by no means follows that the fleas which would have resulted from these eggs would have been troublesome to the human inhabitants of the house; in fact, considering the great zoological difference between man and the cat, the presumption would be in the other direction. It has, however, been asserted, that the cat's flea will attack a human host, but, however that may be, it is evident that, to be on the safe side, rooms in which cats and dogs are accustomed to lie, should be frequently swept, and that the sweepings should be burnt.

From the eggs are hatched, not brown, leaping fleas, but whitish, footless, worm-like maggots, whose bodies are set with long hairs (Fig. 5). Each larva consists of a

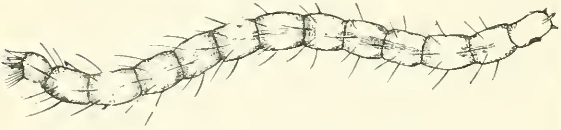


FIG. 5.—LARVA OF CAT'S FLEA (*Pulex felis*). (After Künckel.)

head and twelve segments, the last terminated by a pair of hooks. The head carries four tubercles, a pair of short antennæ, and a good pair of biting jaws (Fig. 6), for at this period of its life the young flea devours solid food; it is neither parasitic nor a blood-sucker. These little grubs are extremely lively creatures, wriggling about vigorously, and working themselves along by aid of their hairs and caudal hooks. They appear to feed upon dry animal substances of various kinds, some fragments of which they are pretty sure to find in the neighbourhood of their birth-place. At the end of the 17th century, Leeuwenhoek, to whom we owe some of the earliest recorded observations on fleas, kept a colony of larvæ, and fed them on the bodies of dead flies. About 50 years later, Rösel tried some larvæ with various substances, and found that they refused sawdust, both from old and fresh wood; and that so far from enjoying fresh blood, they became drowned in it when small quantities that had been extracted from a pigeon were offered them. He found, on the other hand, that they fed readily on the bodies of gnats, and on dried and pulverised blood, and these observations have since been confirmed by other observers. Bearing these facts in mind, then, it is evident that, quite apart from the parasites of our domestic quadrupeds themselves, rugs, mats, or carpets, on which such animals lie, are likely, by the accumulation there of hairs, fragments of skin, &c., to constitute an environment eminently adapted to the propagation of human fleas, the larvæ of which would find there excellent pasturage. In this connection may be quoted an experience of Prof. Westwood, who discovered some larvæ in a very unexpected way. He says that, having dropped a very minute insect on the floor of his library, close to the spot where one of his spaniels was in the habit of lying, he was obliged, in order to find it, to sweep the carpet very carefully with a fine brush upon a piece of white paper. By so doing he found the insect he was in search of, and at the same time swept up what he was certainly not looking for, some small hairy, wriggling maggots, which he at once recognised as flea larvæ. From what he subsequently states, the Professor seems to imply that these were the larvæ, not of the canine species, but of the human flea. The frequent use of the broom, therefore, wherever cats and dogs habitually take up their quarters, is eminently desirable, and not the dustbin, but the fire, should be the final destination of all rubbish so swept up. It is obvious, also, that the frequent sweeping out and cleansing of kennels, especially at the edges and in the corners of the floor, would be helpful as a preventive measure towards ridding dogs of fleas.

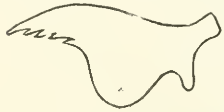


FIG. 6.—BITING JAW OF FLEA'S MAGGOT.

In the form of its larva, the flea is in complete agreement with the order Diptera, the footless, jaw-bearing maggot being the usual type amongst flies.

The young flea does not enjoy a long larval life; in summer it becomes full-grown in about twelve days, and then spins a little cocoon wherein to become a pupa. This habit is apparently sometimes departed from, for Rösel records that some of his larvæ pupated without a cocoon. The cocoon is, of course, extremely minute, and to the silken threads of which it is composed are usually attached particles of dust or cotton or woollen fibre, whereby its identity is almost completely obscured. Inside the snug little abode the tiny maggot divests itself of its larval skin, and appears as an odd, humpbacked chrysalis (Fig. 7). In this the maggot shape has altogether disappeared, and the outline of the perfect form becomes evident. Legs for the first time appear, but they are quite useless, as, in common with the rest of the insect, they are encased in a thin investing pellicle, each leg being enclosed in a case of its own. In the character of its pupa the flea resembles the Hymenoptera (Ants, Bees, Wasps, &c.), and differs markedly from the generality of the Diptera.

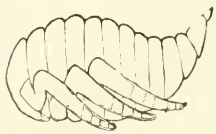


FIG. 7.—PUPA OF FLEA. (After Westwood.)

The developing flea remains in the condition of a pupa about a fortnight, of course taking no food during this time; it is at first dirty white, but soon darkens and assumes the well-known yellowish brown tint of the adult. From this pupa issues the perfect flea, and then, for the first time in its life, the spirit of bloodthirstiness comes upon it; never hitherto have its mouth-organs been adapted for taking liquid food, but now it is furnished with the extraordinary collection of lancets referred to in our former paper, and would find it equally difficult to partake of solid aliment. Those larvæ which hatch from eggs laid towards the beginning of winter do not pass through their metamorphoses so quickly, but spend the winter in the larval state, remaining in a torpid condition till the warmer

weather comes round and wakes them into renewed activity, and enables them to complete their cycle of changes. The flea, then, is an insect with a complete metamorphosis, therein differing *in toto* from both the bed-bug and the cockroach, and agreeing with dipterous flies in general.

Fleas do not seem to be confined to human habitations; there is a common belief that sandy seashores are infested by them, and that visitors to such spots may expect to return home "with company." In support of this notion may be adduced a statement made by Mr. T. J. Bold before the Tyneside Naturalists' Club about twenty-five years ago, to the effect that he saw fleas "dancing about quite merrily between Hartley and Whitley, and at other times they have been noticed quite frequently from South Shields to Marsden." There are, no doubt, many fragments of animal remains scattered about amongst loose sand, such as would serve very well for the larvæ to prey upon; but what the perfect insects can find to live upon in such situations is a mystery, for it can hardly be maintained that they frequent the spot with a view to possible human visitors.

That fleas can be excluded from houses by the use of odoriferous plants has long been a firmly believed tradition; witness the name of our common wayside plant, the Fleabane. The smoke of this when burnt was held to be particularly distasteful to fleas, which would forthwith abandon any premises in which they detected it. Several species of Compositæ have been credited with this potency; a preparation made from the leaves of a *Pyrethrum* from the Caucasus was at one time extensively used in Russia for driving away fleas. Wormwood (Artemisia) also was believed to possess similar powers, and Tusser has the following lines in illustration:—

> While wormwood hath seed, get a handfull or twaine,
> To save against March, to make flea to refraine;
> Where chambere is sweeped and wormwood is strown,
> No flea for his life daro abide to be known.

The "sweeped chambere" had no doubt quite as much to do with the matter as the wormwood. In folk-lore the first of March is intimately associated with fleas. It is still a practice in Kent to keep the doors shut on that day to prevent the fleas from entering, and in Sussex the door-steps are swept on the same day for the same purpose, and thus it is believed that immunity from their attacks will be secured for a twelvemonth.

(*To be continued.*)

THE LIFE-HISTORY OF A FERN.

By E. Mansel Sympson, M.A., M.B. Cantab.

MOST people like ferns, and now-a-days so many people keep them that a brief sketch of the life-history of a fern will probably possess interest for many readers of Knowledge. Ferns belong to the great group of Cryptogams. They owe that name to the fairly obvious fact that in them the organs of reproduction are not so visible, at all events at first sight, as is the case with the Phanerogams or flowering-plants. Another title must be added on to that of Cryptogams, to narrow it down to our more immediate subject. That word is "vascular"; by it we mean that these plants have fibro-vascular bundles in their stems, leaves, and roots (that is to say, supporting fibres and vessels which serve in part for transmitting nourishment from one portion of the plant to another). But our "division" must go farther, for the vascular Cryptogams are divided into Filicinæ (ferns and rhizocarps), Equisetineæ (the Horsetail group), and Lycopodineæ. Beginning, then, with a mature fern, we notice the little brown patches or streaks on the under surface of the fronds of many ferns, such as the Male Fern, the Hart's-tongue, the Polypody or the Maidenhair. These are called sori, and consist of masses of little capsules—the sporangia made up of a thin envelope of cells, save at one part where a thickened band (sometimes merely a small accumulation, as in the Osmunda Fern) extends almost round the capsule. Compare one of these sporangia with one of those watches with

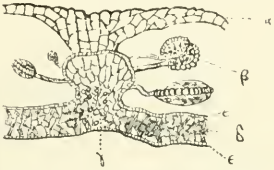


Fig. 1.—Section through a Sorus. α, Cap or Indusium: β, Sporangia; γ, Fibro-vascular bundle; δ, Green parenchyma; ϵ, Epidermis or skin.

Fig. 2.—Prothallium. α, Archegonia; β, Antheridia.

crystal faces and backs which were popular a few years ago. The crystal portion will represent roughly the thin-walled part of the sporangium, while the metal rim running round between the two plates may serve to indicate the position of the annulus, or thickened band of cells. These sporangia, as you might guess from the name, contain the spores, and the annulus plays a very important part in the eviction of these spores. When they are ripe, the ring contracts under certain conditions of the atmosphere, and, as the band is not complete, it tears the thin coat of the cells apart, and turns the spores out in to the world with considerable violence. In some instances these sporangia are covered by a kind of cap, called an indusium, which assumes varied forms; but sometimes it is absent, as in the case of the common Polypody. In each species of fern the spores are all of the same size, and all of them produce, when germinating, almost identical results. This fact, besides others relating to their growth, &c., serves to mark off ferns from the neighbouring order of Rhizocarps, in which there are two kinds of spores macro- and micro-spores—and the product of germination of a large spore differs greatly and invariably from that of a small one. Returning to the fern spores, we notice that they are irregularly shaped bodies, generally dark-brown in colour, having a thin inner coat and a hard and thick outer one. The latter is useful in preventing extremes of weather and temperature from injuring them, and perhaps also in protecting them against the attacks of insects. When the spore has found a suitable resting-place, on a damp surface, with sufficient light and air and warmth, it begins to germinate. It swells up, and puts out a prolongation like a finger, covered by its inner coat, through an aperture in the outer coat, much in the same way as the pollen tube is protruded from the pollen-grain. This finger grows and broadens into a heart-shaped mass, a plate one cell thick, of green uniform cells, containing chlorophyll, and this it is which is commonly known as the prothallium of the fern. A very good idea of its appearance can be obtained from the common liverwort (*Marchantia Polymorpha*) so frequently found in damp court-yards. On the under surface of this prothallium, just behind the notch which gives it its heart

shape, appear the archegonia, which are the female elements of reproduction. Farther back, nearer to the point, so to speak, of the heart, still on the under surface, we find the root hairs, and among them the male elements, the antheridia. The development of these latter, as it is simpler, may be described first. They take their origin from some of the cells forming the plate of the prothallium, as a simple prolongation downwards, just as hairs grow on the stems or other parts of plants. Soon, however, in the middle of the free extremity of each of these, is seen a peculiar round body, of a different colour to the rest of the cell. These bodies rapidly surround themselves with a distinct cell-wall, and subdivide into a number of small cells. In these latter the antherozoids are formed, each consisting of a spirally-coiled thread, thickened at one end, and likewise at that end furnished with six long cilia. In due course the antheridia burst, the cells containing the antherozoids also open, and their contents, which move actively, are discharged. A few brief remarks on the comparative position and relation of these antherozoids will perhaps be in place here before proceeding to describe the development of the archegonia. In one of the lowest groups of Algæ—the Zygosporeæ—*sexual* reproduction as distinguished from vegetative reproduction is effected by the coalescence of two cells to form one, which is called a zygospore to denote its origin. No difference whatever can be observed between the two cells which thus come together; we cannot definitely say that one is male and the other female. At the same time, the mobility of the antherozoid is evidently foreshadowed in the cell which travels towards and pours its contents into the other; and this latter may be considered as representing, even in a rudimentary degree, the female egg-cell—the oosphere. This forms the earliest commencement of a differentiation, or unlikeness, between the male and female elements; a differentiation which proceeds more or less regularly upwards to the ferns, perhaps its highest point, whence it declines to the flowering plants.

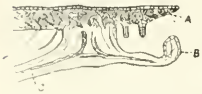


FIG. 3.—SECTION OF PROTHALLIUM AND YOUNG FERN. A, Prothallium; B, First frond; C, First root.

Passing now, with a wide leap, to flowering-plants, we shall see why the word "declines" was used above. In them the pollen-grain, alighting on the stigma, puts forth the pollen-tube into the cellular mass of the stigma. The tube lengthens, and passing through the loosely-compacted tissue of the style, assisted, as has been suggested, by certain projections on the walls of the ovary, it eventually penetrates the micropyle of the ovule. Fertilisation is effected by a certain amount of the contents of the tube fusing with those of the two cells which lie nearest the entrance—the micropyle—and so passing into the oosphere beyond. Before this takes place, however, the protoplasm of the pollen-tube separates itself into an indefinite number of nuclei. These nuclei are the traces, as it were, of the complete cell-formation, which has been described in the development of the antheridia; they are the portions of the male organs of reproduction in flowering-plants which represent, in a degraded state, the antherozoids of which I have been speaking. Thus, from the undifferentiated cell of the humble alga to the highly organised antherozoid of the vascular Cryptogams, we can trace out the successive steps in that differentiation; while we can make out, with more difficulty but yet with comparative certainty, the stages which lead downwards from the antherozoid through the gymnosperms to the mere division of protoplasm in the pollen-tube of angiosperms (flowering-plants). The archegonia of the prothallium of a fern are nearly allied in form to those of the neighbouring order, the mosses. Each consists of a ventral portion, imbedded in the surrounding tissue and coherent with it, and of a short neck, through which two canal cells, as they are called, which subsequently undergo disintegration into mucilage, extend to the egg-cell.

Before describing the development of these archegonia, a brief mention of the comparative anatomy of these canal-cells may be of interest. In animal embryology, you will remember, during the growth of the egg-cell, or ovum, that is to say, during the series of changes whereby it becomes ripe for impregnation by a spermatozoon, two peculiar bodies, called *polar* bodies, are thrown off. These

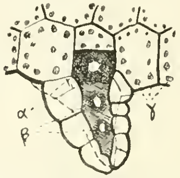


FIG. 4.—ARCHEGONIUM. α, Oosphere; β, Canal-cells; γ, Chlorophyll corpuscles.

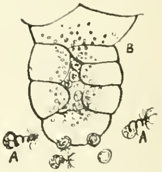


FIG. 5.—ANTHERIDIUM. A, Antherozoids; B, Chlorophyll corpuscles.

polar bodies are derived from the original nucleus of the egg called the germinal vesicle, and the portion of it left behind in the ovum is termed the *female pronucleus*. In the archegonium of a fern the canal-cells, so early severed from the egg-cell, correspond to these same polar bodies in animals, and the only explanation of the why and wherefore of this proceeding in the animal and vegetable economy is that given by the late F. M. Balfour. It is as follows:—After the formation of the polar cells (and the separation of the canal-cells), the remainder of the germinal vesicle within the ovum is incapable of further development without the addition of the nuclear part of the male element (spermatozoon or antherozoid), and he accounts for the prevalence of such a contrivance among plants and animals by assuming that it is to prevent the ovum developing by itself without fertilisation, somewhat analogous to the arrangements in plants to prevent self-fertilisation; the latter being no worse, to say the least, for the plant than the former.

The most frequent place for the spermatozoon to penetrate into the ovum is just where the polar bodies are formed; it seems as though they were guided by their presence, or the trace of them on the outside. Just so through the canal-cells the antherozoid has to make its way to the oosphere within the archegonium, which is composed of a layer of transparent cells, arranged in four tiers, surrounding a central cavity which extends into the thickened portion of the prothallium. Each one is developed from one cell of the prothallium, which swells up above the surface, and is soon separated into two by a horizontal partition. The upper of these two cells thus produced gives rise, by repeated divisions, to the neck of the archegonium, which, when fully developed, is composed of about twelve cells, built up in rings of four, one upon another, so as to form a kind of chimney-shaft having a central passage leading down to a cavity at its base. The lower of those two first formed cells becomes the central cell of the archegonium and, again dividing, cuts off two or more cells which fill up the neck, the canal cells so often mentioned above; while the largest and

lowest of these, remaining at the bottom of the cavity of the archegonium, becomes the oosphere or egg-cell. And from this oosphere, when fertilized by an antherozoid, a young plant is developed, which is what we ordinarily know as the fern. Thus, ferns are subject to what is called alternation of generations. The alternating generations may be distinguished by different names; thus our fern is termed the *sporophore* or spore-bearing generation, and from the perfectly asexual spores it produces is developed the prothallium, the *oophore* or egg-bearing generation, which produces, from the fertilization of the archegonium by the antherozoids of its antheridia, the large and complicated organism commonly known as the fern. The law of alternation of generations seems to be this: that a *sexual* generation, *i.e.* producing sexual organs, alternates with an *asexual* generation which produces only spores. This alternation of generations holds in nearly all the flowering plants. We get the following parts answering in a tolerably exact fashion to the two kinds of spores. The pollen-grain represents the microspore, which pollen-grain gives rise to the pollen-tube corresponding to the antheridium of the microspore's prothallium, while the division of protoplasm of the pollen-tube gives us an indication of the formation of antherozoids. Also, in the pollen-grain of flowering plants, and notably so in that

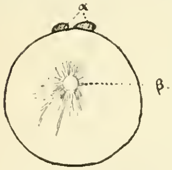


Fig. 6.—Egg of Asterias Glacialis. α, Polar Bodies; β, Female Pronucleus.

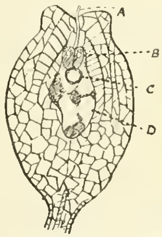


Fig. 7.—Fertilization of a Flowering - plant. A, Pollen tube; B, Synergadae; C, Egg-cell; D, Embryo-sac.

of Gymnosperms, there are two cells, one larger than the other, and usually it is this larger one which pushes itself out as the pollen-tube. Hence, the small cell, the vegetative part of the grain, taking no part in the formation of the pollen-tube, is equivalent to that portion of the prothallium of a microspore which does not produce antheridia; consequently the larger cell of the pollen grain corresponds to the part of the prothallium which does produce antheridia. Again, the embryo-sac of flowering plants, producing as it does by germination the egg-cell, presents a very striking similarity to the macrospore of a rhizocarp, which gives rise to the oosphere in the archegonium of its prothallium; while the merely vegetative portion of the products of the embryo-sac and of the macrospore is in both cases called the endosperm.

Thus from the *sporophore* generation in the rhizocarps we have two kinds of spores giving rise to prothallia—the *oophore* generation—furnished with either antheridia or archegonia, and from the development of the fertilized oosphere in the latter we get the *sporophore*, the rhizocarp, again. Similarly, in flowering plants, the *sporophore* generation is what we know as the plant, producing macrospores, *i.e.* embryo-sacs, and microspores, *i.e.* pollen-grains; these give rise to the *oophore* generation, the prothallia in the one case forming oospheres (the last remnant of archegonia being found in the corpuscula of the Gymnosperms), and in the other, antheridia—the pollen-tube. By the fertilization of the egg by the pollen-tube, the *sporophore* generation is commenced again in the embryo plant, and the two generations, sexual and asexual, continue to repeat themselves in this order over and over again. What are ordinarily called the sexual organs of a flower do not deserve that title, for the stamen is simply a leaf modified to bear microsporangia,—the anthers—whence eventually the male organs will come, while the carpel is only a leaf modified to bear macrosporangia in a somewhat similar way.

We left the oosphere mature and ready for fertilisation by the antherozoids. They enter the canal of the archegonium, and as soon as the oosphere has been fertilised by them it begins to divide into four cells; of these the two lowest sub-divide into a plug-like, cellular mass, which imbeds itself firmly in the substance of the prothallium. Probably this, called the *foot*, takes up nourishment for the embryo from the prothallium. It also serves to distinguish cryptogams of the most differentiated kind from flowering plants generally, for in all the latter the *suspensor* is the organ corresponding to this foot. In some orchids this suspensor curiously enough actually grows out of the micropyle into the placenta, to absorb nutriment for the embryo. In several of the flowering plants the use of the suspensor seems to finish after a certain period, and its place is taken by what Dr. Charles Darwin termed "the peg," between the plumule and the radicle. The presence of this peg has rather complicated the subject, but Dr. Vines has been able to show, by comparative studies, that the suspensor of selaginella and of the flowering plants is homologous with the foot of the vascular cryptogams, seeing that it is derived from the same cell of the embryo. Of the remaining two upper cells, which also sub-divide, one gives rise to the rhizome—the stem of the young fern—while the other becomes its first rootlet. As the rhizome grows and develops its fronds, it rapidly attains a size vastly superior to that of the prothallium, which ceases to have any work to do, and disappears.

SOME PROPERTIES OF NUMBERS.

By Robt. W. D. Christie, Head Master, Wavertree Park College, Liverpool (Member of the Lond. Math. Soc., &c.).

Roots and Powers of Numbers.

Is the square root of 1234567 an integer? No; because the square of no integer can possibly end in the digits 2, 3, 7 or 8. This is easily shown as follows: Square the ten digits 1, 2, 3, &c. successively, and we get numbers ending in all the digits except those given above, viz. the digits 0, 1, 4, 9, 6, 5.

The cube of an integer may end in any of the ten digits. It is curious, however, to note that the cube of any integer ending in the same six digits, viz. 0, 1, 4, 9, 6, 5, ends in the same digit as the number itself does; and moreover the cube of any integer ending in the four digits mentioned above, viz. 2, 3, 7, 8, ends in the same figures but in the reverse order 8, 7, 3, 2.

We can thus very easily determine by inspection the cube root of any perfect cube less than a million. *Ex. gr.*, Find the cube root of 912673 by inspection.

Pointing off as usual, we see at once that there must be two figures in the root, and that one of them is 7 (since the cube of 7 ends in 3), and the nearest cube root of 912 is 9; thus we easily get 97 as the required root

The fourth power of an integer may end in the four

digits 0, 1, 6, 5 only, and consequently no integer ending in 2, 3, 4, 7, 8, 9 can have its fourth root an integer. It is useful to note that the fourth power of any prime (except 2 and 5) ends in *unity*. Thus $P^4 - p^4$ is divisible by 240, at least when P and p are prime numbers > 5.

Any power of 5, 6, or 10 or number ending in 5, 6, 0 ends in 5, 6 or 0. Also, since $5 = 1^2 + 2^2$, we have by Euler's Theorem 5^n = the sum of two integral squares where n is any integer whatever.

Thus $5^2 = 3^2 + 4^2$; $5^3 = 2^2 + 11^2 = 5^2 + 10^2$, &c. &c.

It is remarkable that the fifth power of any number ends in the same integer as the number itself does, thus $1^5 = 1$; $2^5 = 32$; $3^5 = 243$, &c.

This fact can be utilised:—The fifth root of 17,210,368 is an integer. Determine it by inspection. Pointing off as usual, we have two figures in the root, and the units' digits must be 8 for the reason given. And since 3^5 is > 172 we must have 2 in the tens' place. Thus we get 28 for the fifth root.

Again, Ball in his *History of Mathematics*, p. 262, says:—"There is no integral solution of the equation $x^n + y^n = z^n$ if n is any integer > 2. Euler proved it when $n = 3$, and Lagrange gives a proof when $n = 4$. It appears to be generally true. The riddle therefore awaits a solution."

Now, if $x^5 + y^5 = z^5$, and all are integers, we must also have $x + y = z$, or $(10m + z)$, and the equation may be solved.

If we proceed with the sixth, seventh, &c. powers of numbers, we shall find they are but repetitions of the squares, cubes, &c. So that we have the first, fifth, ninth — $4n - 3$rd power of an integer ending in the same digit as the number itself.

Similarly $N^{2(2n-1)}$ cannot end in the digits 2, 3, 7, 8, but N^{4n-1} may end in *any* digit, and N^{4n} can only end in the digits 0, 1, 6, 5.

Circulating Decimals.

There is evidently a close connection between Prime Numbers and Circulating Decimals. The rules relating to the conversion of vulgar fractions into decimals are generally ignored in the ordinary arithmetics on account of their number and intricacy. In order to determine the pericdicity of any vulgar fraction $1/N$ we can reduce the rules to two. If the vulgar fraction be of the Form $1/N = 1/2^x 5^y$ the decimal *terminates* after p figures from the decimal point, p being the greater of the numbers x and y. In all other cases it will *recur*, *e.g.* let $x = 3$, $y = 2$, then $1/N = 1/2^3 5^2 = 1/200 = \cdot 005$.

If $1/N$ be the vulgar fraction where N ends in any one of the digits 1, 3, 7, or 9 then if $(10^p - 1)/N$ or $(N^p + N - 1)/N$ be an integer p will give the periodicity. Thus, *e.g.*, if $N = 13$ we have $(10^p - 1)/13$ or $(4^p + 12)/13$ an integer when $p = 6$. Thus the number of figures in the period of $\frac{1}{13}$ will be 6.

Since the vulgar fraction is always supposed to be brought down to its lowest terms, a numerator would not affect the periodicity. The rule as usually given can only tell us that the number of figures in the period is equal either to $\phi(N)$ or to a sub multiple of $\phi(N)$ where $\phi(N)$ denotes the totitives of N, *i.e.* the number of numbers less than N and prime to it.

It is a curious fact that when N is a prime, the figures of the period of $1/N$ are divisible by 9. When the period is *even* it is also divisible by 11, and when the period contains $3n$ figures by 37, &c. This will be enlarged upon in a future number. Thus *e.g.* $\frac{1}{37} = \cdot\dot{0}2\dot{7}$ and $0 + 2 + 7 = 9$; $\frac{1}{41} = \cdot\dot{0}243\dot{9}$ and $0 + 2 + 4 + 3 + 9 = 18$; $\frac{1}{31} = \cdot 076923 = 27$; $\frac{1}{79} = \cdot 0126582278481 = 54$; also $\frac{1}{53}$: $\frac{1}{73}$, &c. &c.

Of course this is true generally when the period contains $N - 1$ figures. We may also note such fractions as $\frac{1}{63} = \cdot\dot{0}1587\dot{3}$, where the second half is complementary to the first. Thus $3 + 5 = 8$; $7 + 1 = 8$; $8 + 0 = 8$; similarly $\frac{1}{47} = \cdot 00851\dot{7}$ gives us 555; $\frac{1}{21}$ give us 666, &c. &c.

I am now in a position to show one advantage that the method of division given in the November issue has over the ordinary method.

Find the periodicity of $\frac{1}{61}$. I set four boys simultaneously to work. Two do the first and third portions simultaneously by the ordinary method of division, and two others work the second and fourth portions by the new method till the figures meet or overlap. I then test the result by the nines.

Thus A's work would be to divide 1·000 + by 61 = fifteen figures.

B's work would be to *multiply* by 6 and point off till he has fifteen figures, as explained in the November issue, thus:—

```
1000·0+
     6
 99·4
 24
97·5
30
 7
```

Thus we have +7540 = last four figures of 2nd portion.

C's work will be to divide 60·000 + by 61 to fifteen figures, and D will multiply by 6 as follows by the new method:—

```
+ 999·9
     54
   94·5
   30
  96·4
  24
  7·2
```

Thus we have +2459 = last four figures of period.

The test is—

```
+ 7540
+ 2459
+ 9999
```

We can thus set four boys to work one division question simultaneously, and it is interesting to note that we are able to obtain the middle figures of a quotient, and to work the question each way till the whole result is obtained. The full result is $\frac{1}{61}$ = ·016393442622950 (A), 819672131147540 (B); 983606557377049 (C), 180327868852459 (D) = 9999 +, &c., if A and C and B and D be added together. This result may be obtained in a much easier manner, as will be explained in another paper.

I will now describe a method of writing down mechanically the figures of the period of $1/N$ where N is a prime.

Primes > 5 end in the figures 1, 3, 7, or 9 only. It is easy to deduce from this that the last figure of the period of $1/N$ must be 9, 3, 7, or 1, respectively. Let us take $\frac{1}{19}$ for example. The *last* figure, according to the rule just given, is 1. All we have to do now is to multiply that 1 by 2; then multiply the product 2 by 2; then the product 4 by 2, and so on till the figures *repeat*. Thus the full period is $\frac{1}{19} = \cdot\dot{0}5263157894736842\dot{1}$.

Again, write down mechanically the period of $\frac{1}{29}$. Multiply the last figure, which is 1, by 3. Then the product 3 by 3, and so on as before. Thus we get $\frac{1}{29} = \cdot\dot{0}34482758620689655172413793\dot{1}$.

It is remarkable how interesting the dreariest part of arithmetic becomes when scientifically investigated.

This method suffices not only for Primes, but also for all numbers ending in the digits 1, 3, 7, or 9. But some-one may say, How do you get the multipliers after you have obtained your last figure of the period? Nothing is easier. If your number N ends in 9 take the tens and add one. Thus, for $\frac{1}{79}$ our multiplier is 8 (since $7+1=8$), and we get the period of $\frac{1}{79}=\cdot\dot{0}12658227848\dot{1}$.

For numbers ending in unity take the tens from the given number. Thus for $\frac{1}{41}$ take 4 from 41 = 37, which is our multiplier, and $\frac{1}{41}=\cdot\dot{0}243\dot{9}$.

For numbers ending in 3 multiply by 7, and for numbers ending in 7 multiply by 3, and in either case take the tens' digit from the given number. Thus, for $\frac{1}{13}$ we have 13 − 9 = 4, and the period $=\cdot\dot{0}7692\dot{3}$, and the multiplier for 17 is 12. Thus, $\frac{1}{17}=\cdot\dot{0}58823529411764\dot{7}$.

This remarkable rule is intimately connected with the new method of division, an elementary explanation of which I now give.

Let $N=PR$; say $2091=17R$.

$3N=3PR=10M_1+n_1$; say $6273=51R=10\times627+3$.

Let $X=(3P-1)/10$ say $5=(3\times17-1)/10$ in this case.

Then $3NX=3PRX=10M_1X+n_1X$.

And consequently $PR_1=M_1-n_1X$;

Say $17R_1=627-3\times5=612=10M_2+n_2$.

Similarly $PR_2=M_2-n_2X$;

Say $17R_2=61-2\times5=51=10M_3+n_3$.

Also $PR_3=M_3-n_3X$; say $17R_3=5-1\times5=0=10M_4+n_4$.

Now compare the process with the method described.

$$\begin{array}{rl}
627\cdot3 & =17R=10M_1+n_1 \\
15 & \\
\hline
61\cdot2 & =17R_1=10M_2+n_2 \\
10 & \\
\hline
5\cdot1 & =17R_2=10M_3+n_3 \\
5 & \\
\hline
0 & =17R_3
\end{array}$$

Thus $2091\div17=123$.

Proceeding to the general case we get

$$PR_m=M_m-n_mX=10M_{m+1}+n_{m+1}.$$

Again we have—$M_1-n_1X=10M_2+n_2$.

Thus—$M_1-10M_2=n_1X+n_2$ . . . (1).

Again—$M_2-n_2X=10M_3+n_3$ . . . (2).

Thus—$10M_2=100M_3+10n_3+10n_2X$.

Therefore $M_1=100M_3+10n_3+10n_2X+n_1X+n_2$ (1 & 2).

$\therefore 3N=1000M_3+100R_3+100n_2X+10\,n_1X+10n_2+n_1$.

But $M_3=n_3X$.

Thus—$3N=(10Y+1)\,(100n_3+10n_2+n_1)$.

That is—$N=P\,(10n_3+10n_2+n_1)$.

And generally—$N=P\,(10^{m-1}_{n_m}+10^{m-2}_{n_{m-1}}\ .\ .\ .\ +_1)$.

The above is a proof for any divisor ending in 7. The process is exactly the same for divisors ending in 1, 3, or 9, and the only difference is in the value of X.

(To be continued.)

GROWTH AND DECAY OF MIND.

By the late R. A. Proctor.

(Continued from page 33.)

PERHAPS no more remarkable instance could be cited of the the possession of power in old age with the want of elasticity referred to in the last paper—than the remarkable papers on the universe, written by Sir W. Herschel in the years 1817 and 1818, that is, in his seventy-ninth and eightieth years. We find the veteran astronomer proceeding in the path which, more than forty years before, he had marked out for himself; but the very steadiness and strength of purpose with which he pursues it indicates the degree to which his mind had lost its wonted elasticity. In 1784 and 1785 he was traversing a portion of the same road. But then he was in the prime of his powers, and accordingly we recognise a versatility which enabled him to test and reject the methods of research which presented themselves to his mind. It was in those years that he invented his famous method of star-gauging, which our text-books of astronomy preposterously adopt as if it were an established and recognised method of scientific research. But Herschel himself, after trying it, and satisfying himself that it was unsound in principle, abandoned it altogether. In 1817 he adopted a method of research equally requiring to be tested, and, in my conviction, equally incapable of standing the test; but he now worked upon the plan he had devised, without subjecting it to any test. Nay, results which only a few years before he would certainly have rejected—for he did then actually reject results which were open to the same objection—passed muster in 1817 and 1818, and are recorded in his papers of those dates without comment. We may recognise another illustration of the loss of elasticity with advancing years, in the obstinacy—one may even say the perversity—with which Sir Isaac Newton, in the latter years of his life, adhered to opinions on certain points where, as has since been shown, he was unquestionably wrong, and where, had he possessed his former mental versatility, he must have perceived as much. Compare this with his conduct in earlier years, when for nineteen years he allowed his theory of gravitation to rest in abeyance—though he had fully recognised its surpassing importance—simply because certain minute details were not satisfactorily accounted for. Many other instances might be cited, were it worth while, to show how the mind commonly changes when approaching an advanced age, in a manner corresponding to that bodily change—that stiffness and want of elasticity, without any marked loss of power, which comes on with advancing years. That old age does not necessarily involve any loss of power for routine work, has been clearly shown in the lives of many eminent men of our own era.

It is well pointed out by Dr. Beard, in the lecture to which I have already referred, that "we must not expect to find at one age the mental qualifications due to another age—we must not look for experience and caution in youth, or for suppleness and versatility in age. We ought also to apportion to the various ages of a man the kind of work most suitable to them. Positions which require mainly enthusiasm and original work should be filled by the young and middle-aged; positions that require mainly experience and routine work, should be filled by those in mature and advanced life, or (as in clerkships) by the young who have not yet reached the golden decade. The enormous stupidity, and backwardness, and red-tapeism of all departments of governments everywhere, are partly due to the fact that they are too much controlled by age. The conservatism and inferiority of colleges are similarly explained. Some of those who control the policy of colleges—presidents and trustees—should be young and middle-aged. Journalism, on the other hand, has suffered from relative excess of youth and enthusiasm."

Before passing from the lecture of Dr. Beard, I shall venture to quote the remarks which he makes on the evidence sometimes afforded of approaching mental decay by a decline in moral sensitiveness. "Moral decline in old age," he says "means—'Take care; for the brain is giving way.' It is very frequently accompanied or preceded by sleeplessness. Decline of the moral faculties, like the decline of other functions, may be relieved,

retarded, and sometimes cured by proper medical treatment, and especially by hygiene. In youth, middle age, and even in advanced age, one may suffer for years from disorders of the nervous system that cause derangement of some one or many of the moral faculties, and perfectly recover. The symptoms should be taken early, and treated like any other physical disease. Our best asylums are now acting upon this principle, and with good success. Medical treatment is almost powerless without hygiene. Study the divine art of taking it easy. Men often die as trees die, slowly, and at the top first. As the moral and reasoning faculties are the highest, most complex, and most delicate development of human nature, they are the first to show signs of cerebral disease. When they begin to decay in advanced life, we are generally safe in predicting that, if these signs are neglected, other functions will sooner or later be impaired. When conscience is gone, the constitution is threatened. Everybody has observed that greediness, ill-temper, despondency, are often the first and only symptoms that disease is coming upon us. The moral nature is a delicate barometer, that foretells long beforehand the coming storm in the system. Moral decline as a symptom of cerebral disease is, to say the least, as reliable as are many of the symptoms by which physicians are accustomed to make a diagnosis of various diseases of the bodily organs. When moral is associated with mental decline in advanced life, it is almost safe to make a diagnosis of cerebral disease. . . . . Let nothing deprive us of our sleep. Early to bed and late to rise, makes the modern toiler healthy and wise. The problem for the future is to work hard, and at the same time to take it easy. The more we have to do, the more we should sleep. Let it never be forgotten that death in the aged is more frequently a slow process than an event; a man may begin to die ten or fifteen years before he is buried."

When mental decay is nearing the final stage, there is a tendency to revert to the thoughts and impressions of former years, which is probably dependent on the processes by which the substance of the brain is undergoing decay. The more recent formations are the first, as we have seen, to crumble away, and the process not only brings to the surface, if we may so speak, the earlier formations—that is, the material records of earlier mental processes—but would appear to bring those parts of the cerebrum into renewed activity. Thus, as death draws near, men "babble of green fields," as has been beautifully said, though not by Shakespeare, of old Jack Falstaff. Or less pleasant associations may be aroused, as we see in Mrs. Grandmother Smallweed, when "with such infantine graces as a total want of observation, memory, understanding, and intellect, and an eternal disposition to fall asleep over the fire and into it," she "wiled away the rosy hours" with continual allusions to money.

The recollections aroused at the moment of death are sometimes singularly affecting. None can read without emotion the last scenes of the life of Colonel Newcome. I say the last scenes, not the last scene only, though that is the most beautiful of all. Everyone knows those last pages by heart, yet I cannot forbear from quoting a few sentences from them. "'Father!' cries Clive, 'do you remember Orme's *History of India*?' 'Orme's History, of course I do; I could repeat whole pages of it when I was a boy,' says the old man, and began forthwith. '"The two battalions advanced against each other cannonading, until the French, coming to a hollow way, imagined the English would not venture to pass it. But Major Lawrence ordered the sepoys and artillery—the sepoys and artillery to halt, and defend the convoy against the Morattoes." Morattoes, Orme calls them. Ho! Ho! I could repeat whole pages, sir.'" Later, "Thomas Newcome began to wander more and more. He talked louder; he gave the word of command, and spoke Hindustanee, as if to his men. Then he spoke words in French rapidly, seizing a hand which was near him, and crying, 'Toujours, toujours.' But it was Ethel's hand which he took. . . . . Some time afterwards, Ethel came in with a scared face to our pale group. 'He is calling for you again, dear lady,' she said, going up to Madame de Florac, who was still kneeling. 'And just now he said he wanted Pendennis to take care of his boy. He will not know you.' She hid her tears as she spoke. She went into the room, where Clive was at the bed's foot; the old man within it talked on rapidly for awhile; then again he would sigh and be still: once more I heard him say hurriedly, 'Take care of him when I'm in India,' and then with a heart-rending voice he called out 'Léonore, Léonore.' She was kneeling at his side now. The patient's voice sank into faint murmurs; only a moan now and then announced that he was not asleep. At the usual evening hour the chapel bell began to toll, and Thomas Newcome's hands outside the bed feebly beat time. And just as the last bell struck, a peculiar sweet smile shone over his face, and he lifted up his head a little, and quickly said, 'Adsum!' and fell back. It was the word we used at school when names were called, and lo! he whose heart was as that of a child, had answered to his name, and stood in the presence of The Master."

Sadder than death is it, however, when the brain perishes before the body. "How often, alas, we see," says Wendell Holmes, "the mighty satirist tamed into oblivious imbecility; the great scholar wandering without sense of time or place, among his alcoves, taking his books one by one from the shelves and fondly patting them: a child once more among his toys, but a child whose to-morrows come hungry, and not fullhanded come as birds of prey in the place of the sweet singers of the morning. We must all become as little children if we live long enough; but how blank an existence the wrinkled infant must carry into the kingdom of heaven, if the Power that gave him memory does not repeat the miracle by restoring it."

TORTOISES AND TURTLES.

By R. LYDEKKER, B.A. Cantab.

TO many of us, the chief idea connected with turtles is that they are used to make turtle-soup; while in regard to tortoises our acquaintanceship is often limited to seeing a barrow-load of unfortunate specimens hawked about the streets, or to an individual or two kept in our own or a friend's garden, as a very unsociable kind of pet. We are also acquainted with this group of animals by means of tortoise-shell, either in the form of combs or various ornamental articles; although the exact nature of this commodity—which, by the way, comes from turtles and not from tortoises—is very frequently but very imperfectly known. Many people, indeed, have more or less hazy ideas as to what kind of animals tortoises and turtles really are. Thus, according to *Punch*, railway companies classify tortoises as insects; and the writer well recollects that during his undergraduate days his landlady purchased an unfortunate tortoise to take the place of a deceased hedgehog in the kitchen, for the purpose of eating black-beetles, and was immensely astonished when told that the tortoise was a vegetable feeder and had no sort of kinship with the hedgehog.

Tortoises and turtles, or, as it is frequently convenient to call them, Chelonians (from the Greek name of the turtle), are, however, in reality a very remarkable group, or order, of the great class of Reptiles; and their form is so peculiar and so interesting that a short glance at some of their chief structural features cannot fail to be instructive. We are, indeed, accustomed to regard many extinct groups of reptiles, like the Fish-lizards* of the Secondary rocks, as more *bizarre* and strange than any forms which now inhabit the globe; but if we were to be made acquainted for the first time with tortoises from their fossil remains, we should certainly consider them as far more extraordinary than any other types; and it is highly probable that the palæontologist who first made known such a remarkable type of reptilian structure would be charged with having created a totally impossible monster.

The most striking and peculiar feature about tortoises and turtles is the more or less complete bony shell with which their body is protected; and on account of which they are noticed in the article on "Mail-clad Animals" published in the December number of Knowledge. The accompanying woodcut (Fig. 1) exhibits a typical Chelonian, as exemplified by a land-tortoise. In this creature we see a fully developed bony shell, within which the head, limbs, and tail can be retracted, so as to afford a perfect protection for the entire animal. We have just said that the shell of the tortoise is a bony one; but it will probably be at once objected that the "tortoise-shell" of commerce is about as unlike bone as it can well be. This apparent discrepancy can, however, be very readily explained. In a living tortoise, as is well shown in Fig. 1, the outer surface of the shell is completely covered over with a series of large shield-like horny plates, of which there is one row down the middle of the back, a lateral row on either side of this middle one; externally to which we have a series of marginal shields, forming the border of the upper half of the shell. Similar horny shields also cover the lower part of the shell, which we shall notice shortly. The solid bony shell underlies these horny shields; the relations of the horny and bony constituents of the protecting shell being shown in Fig. 2, where the outer horny shields have been stripped off, leaving distinct grooves on the underlying bones at the lines of junction with one another. Now it is these horny shields which form the "tortoise-shell" of commerce; in the land-tortoises they are, indeed, very thin, and of no economical value, but in one of the marine turtles, known as the Hawksbill, they become greatly thickened, and furnish the well-known "tortoise-shell," so remarkable for its translucency and the beautiful colouration formed by the mottled blending of a full reddish brown with a lemon yellow. It will be noticed from Fig. 1 that in the land-tortoises these horny shields have their edges in apposition; but in the young of the Hawksbill turtle they overlap one another like the slates on a roof, although in the adult they become united by their edges in the same manner as in the tortoises.

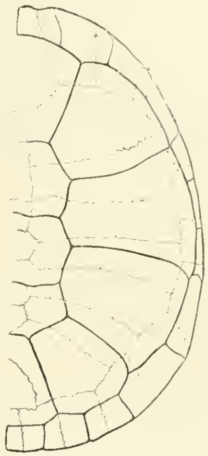


Fig. 2.—The Right Half of the Upper Shell, or Carapace, of a Tortoise, with the Horny Shields removed. The thick black lines show the boundaries of the horny shields, while the zigzag lines indicate the divisions between the underlying bony elements of the shell.

Fig. 3.—The Middle and Left Side of the Lower Shell, or Plastron, of a Land-Tortoise.

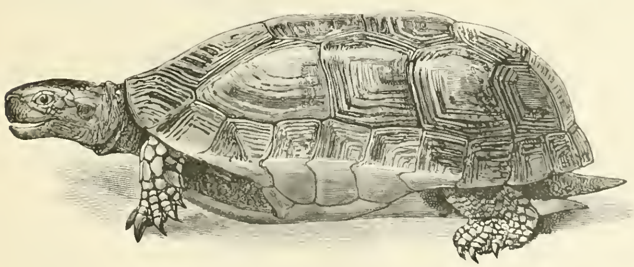


Fig. 1.—Side View of a Land-Tortoise, with the Head and Limbs protruded from the Shell.

Turning once more to Fig. 1, it will be seen, as we have already incidentally mentioned, that the shell consists of an upper vaulted portion covering the sides and back, which is technically known as the *carapace*; and also of a flattened lower plate protecting the chest and abdomen, to which the term *plastron*, or breast-plate, is applied. The carapace and the plastron are usually connected together by a comparatively short bony bridge, at the extremities of which are the notches for the fore and hind limbs, as is well shown in Fig. 1. In the land-tortoises this union between the carapace and plastron is quite complete; but in the marine-turtles, and also in some freshwater-tortoises, there is no bony union between the upper and lower portions of the shell. The characters of the plastron of the land-tortoises are well shown in Fig. 3, from which it will be seen that there are six pairs of symmetrical horny shields, arranged on either side of the middle line of the shell. This type of plastron is characteristic of nearly all the tortoises of the northern hemisphere; but in a smaller group, now confined to the southern hemisphere, there is an additional unpaired shield (Fig. 4, *i*, *gu*) dividing the

* See Knowledge for November 1889.

first or gular (*gu*) shields of the plastron. This additional, or intergular, shield, as it is termed, is very frequently of a battledore shape, as in Fig. 4.

In regard to the bones composing the upper shell, or carapace, it will be observed, from Fig. 2, that although they by no means correspond in contour with the overlying horny shields, yet that a decided general similarity of arrangement obtains between the two. Thus there is a single middle row of bones corresponding to the middle row of horny shields, although the bones are smaller and more numerous than the shields. Similarly there is a series of lateral bones on either side of the middle row; while in like manner the border of the carapace is formed

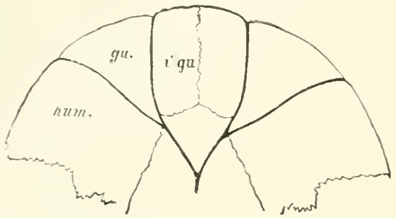


Fig. 4.—The Front Portion of the Carapace of a Freshwater-Tortoise of the Southern Hemisphere, with the Horny Shields removed. The thick lines indicate the boundaries of the horny shields.

of a series of marginal bones corresponding very closely with the marginal horny shields. The middle series of bones of the carapace are severally attached to the summits of the spines of the back-bone or vertebræ; while the lateral bones are nothing more than large expanded plates lying on the ribs, to which they are so completely welded that they are generally regarded as part of the same bone.

From this very brief glance at the structure of the Chelonian shell, we are now enabled to understand one of the most peculiar features of the organisation of these remarkable reptiles. This peculiar feature is, that whereas the shoulder-blade in all other animals lies entirely on the outer side of the ribs, in the tortoises and turtles it is situated within the cavity enclosed by the ribs and shell. Similarly the haunch-bones, which in all other animals lie close to the outer surface of the body, are likewise shifted within the cavity of the ribs and shell. To reach the shoulder-blades and haunch-bones the bones of the arm and leg are bent in a manner quite peculiar to this group of reptiles.

One other peculiarity in the bony structure of the group still remains to be mentioned. It is probably well known to all our readers that ordinary reptiles—such as crocodiles and lizards—are furnished with well developed teeth, which are frequently of great size. In all Chelonians, on the contrary, teeth are totally wanting, and their function is consequently performed by the margins of the jaws, which form sharp cutting edges, and are ensheathed with a coating of thick horn. This total absence of teeth is well shown in Fig. 1, and still better in Fig. 5, where the bones of the skull are represented with the flesh and skin removed. Another remarkable peculiarity of the Chelonian skull is found in the circumstance that the two sides of the lower jaw are firmly united together by bone at the chin, instead of being more or less completely separated, as in all other living reptiles. A third peculiarity is the development of the hinder extremity of the skull into a long spike-like process (Fig. 5, *o*), which gives a very characteristic contour to this part. The whole of the skull is covered over with horny shields (Fig. 1) in the living animal; so that in this respect the structure of the skull corresponds exactly with that of the shell.

In the entire absence of teeth, coupled with the horny sheathing of the jaw, and the solid union of the two bones of the lower jaw at the chin, tortoises agree with birds. Many, or all, of the birds of the Secondary geological epoch are, however, now known to have been provided with a complete set of teeth, and it is therefore highly probable that we shall some day find the fossil remains of extinct tortoises which were also furnished with these useful implements, since there appears to have been a tendency in many groups of animals, and more especially in birds and their near relations the reptiles, to lose their teeth. Thus the Fish-lizards of the Cretaceous rocks of the United States are all characterised by the absence of teeth; and a similar condition obtains in the Pterodactyles, or flying reptiles of the same deposits, by which feature they are widely distinguished from their Old World allies.

All the fossil tortoises and turtles at present known to us agree with existing types in their absence of teeth, as well as in the general characters of the shell; and we have at present (on the assumption that some mode of evolution is the true explanation of the mutual relationships of the different groups of animals) no evidence to connect the Chelonians very closely with any other type of reptiles. It is, however, very probable that the bony plastron of the tortoises is an extreme development of the peculiar system of so-called abdominal ribs found on the lower surface of the body in crocodiles and many extinct groups of reptiles.

Chelonians vary greatly in their habits, and in the nature of their food. Thus the land-tortoises, as their name implies, are terrestrial, although all of them can swim; while some closely allied types are aquatic. The feet of the former are provided with strong claws, and their food consists exclusively of vegetables, of which they consume a vast amount. The pond-tortoise of Southern Europe, which, together with the common Grecian land-

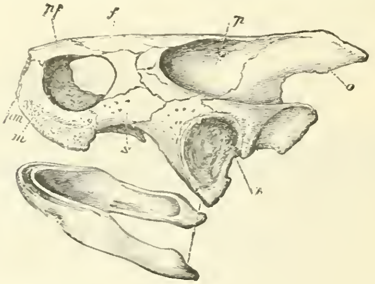


Fig. 5.—Left Side of the Skull of a Tortoise, with the Lower Jaw Displaced. *m*, *pm*, upper jaw; *s*, cheekbone; *t*, cavity of ear; *f*, *pf*, bones over the eye and nose-cavity; *p*, hollow of the temples; *o*, posterior spine.

tortoise, is the only European representative of the group, has, however, the feet webbed, and subsists on animal substances, such as worms. Many of the Indian water-tortoises are also carnivorous; this being especially the case with the well-known soft tortoises of the rivers of the warmer parts of the globe. In these forms the shell is unprovided with horny shields, but has the outer surface of the bones ornamented with a beautiful net-like sculpture, and merely covered with a thin skin. In the turtles, again, which are of marine habits, although they

Photograph of Harvard College Observatory (taken through a Pinhole without a Lens).

resort to the shore to deposit their eggs, the limbs have all the toes enclosed in a common sealy integument, and these form paddles admirably adapted for swimming organs. While, however, the edible Green-turtle is of strictly herbivorous habits, the fierce Hawksbill is purely carnivorous. Another very remarkable group of marine Chelonians is now represented only by the so-called Leathery-turtle, which differs from all other living forms in that the shell is represented only by a carapace composed of a number of small bones closely joined together, and forming a mosaic-like structure which is totally unconnected with the ribs. The living Leathery-turtle attains a length of about five feet; but some allied fossil forms are estimated to have been as much as ten feet in length, and were thus veritable aquatic giants. The largest existing representatives of the true tortoises are, or were recently, found in certain islands of the Indian Ocean, and also in the well-known Galapagos (or Tortoise) Islands lying off the coast of South America. A magnificent series of these giant land-tortoises is now exhibited in the Natural History Museum at South Kensington. Many of these huge creatures, which have in some cases been completely exterminated by sailors, could readily walk off with a man seated on their back; and in the larger forms the length of the shell in a straight line is upwards of four feet. These dimensions were, however, vastly exceeded by certain fossil species found both in Northern India, the south of France, and elsewhere; the shells of some of these monsters attaining a length of six feet. The late Dr. Falconer, who was disposed to consider that the size was considerably greater than this, has indeed suggested that some of these huge tortoises may have lived on in India into the human period, and thus have given rise to the old Sanscrit legend that the earth was supported by a gigantic elephant standing upon the back of a still more gigantic tortoise; the legend being silent as to what constituted the support for the tortoise.

In conclusion, we may say a few words as to the classification of Chelonians, leaving, however, out of consideration the leathery-turtle and its allies, in regard to the serial position of which there has been been a considerable amount of discussion. Ordinary Chelonians are readily divided into two great groups, according to the manner in which the head is retracted within the shell. Thus, in the land-tortoises (Fig. 1) and their allies, the head is drawn directly within the margin of the shell by the bending of the neck in an **S**-like manner in a vertical plane. The plastron of this group is generally characterised by the absence of the unpaired intergular shield (Fig. 3), so that the two gular shields meet in the middle line. This group, as we have already mentioned, includes all the tortoises of the Northern Hemisphere, with the exception of the soft tortoises, and also the marine-turtles; it is, however, by no means confined to this hemisphere, although it is totally wanting in Australia. The name Cryptodirans, or hidden-neck tortoises, is applied to the members of this group. In the second great group, on the other hand, the neck is bent sideways, so that the head, when retracted, lies on one side of the front aperture of the shell near to one of the legs; and the presence of an intergular shield in the plastron (Fig. 4) is absolutely characteristic. The members of this group are termed Plurodirans, or side-necked tortoises, and, as we have said, are now exclusively confined to the Southern Hemisphere, and are the only Chelonians met with in Australia. In former epochs this group was, however, much more widely distributed, from which we may probably conclude that the Pleurodirans are an older and less specialised type than the Cryptodirans. A very remarkable gigantic fossil tortoise from Queensland and Lord Howe Island, which may probably be regarded as a member of the Pleurodiran section, is remarkable for having large horn-like prominences on the skull, and also for the bony rings with which the tail was protected, somewhat after the fashion of the Glyptodont Mammals (*see* Knowledge for December). Finally, the soft tortoises form a third group, allied to the Cryptodirans in the mode of retraction of the head, but distinguished by certain peculiarities in the structure of the skull and shell. From the presence of only three claws on the feet of the typical forms, this group is technically termed the Trionychoidea; and with this group we bring our brief remarks on tortoises to a close.

HARVARD COLLEGE OBSERVATORY.

By A. C. Ranyard.

The accompanying plate was made from a photograph sent me by Prof. W. H. Pickering. It represents the rear of the celebrated Observatory of Harvard College, which is situated on a hill at Cambridge, a suburb of Boston, Massachusetts. The photograph was taken by Prof. W. H. Pickering without a lens. The image which fell upon the sensitive plate was formed by light from a pin-hole in the front of the camera; but though the sun was nearly setting when the photograph was taken, the exposure was only six minutes. The photograph was taken from the roof of a cottage to the northwest of the Observatory, and it will be noticed that the slates of the roof, and the wires, and other objects in the immediate foreground (with the exception of the fir trees, which probably moved with the wind during the exposure), are equally as sharp as objects at a distance. There being no lens, all objects are equally in focus and there is no distortion, or rather there is the same distortion as there should theoretically be in a hand-drawn picture; all objects appear as they would be seen projected on the tangent plane to a sphere by an eye situated at the centre of the sphere.

A photograph of any size may be taken with such an arrangement, but the farther the plate is from the pinhole the larger will be the image of the object photographed, and the longer will be the time of exposure. Lord Rayleigh has shown that photographs may be obtained with holes considerably larger than pinholes, provided the plate is removed to a distance of some feet—the condition of sharp definition being that waves from different parts of the hole shall not interfere. No perceptible diminution in the sharpness of the image is apparent when the distance of the plate from different parts of the hole is less than a quarter of a wave length. The small observatories in the foreground contain various photographic instruments; that to the right contains an 11-inch photographic refractor, and the central dome covers Dr. Henry Draper's 28-inch silver or glass reflector; the other domes and huts cover the instruments with which Professor C. E. Pickering's photometric survey of the heavens has been made, as well as the instruments with which the series of photographs of stellar spectra have been taken.

The large dome at the centre of the main building covers the 15-inch refractor formerly used by Bond, which was in its day the largest instrument in America, and shared with the old 15-inch refractor of the St. Petersburg Observatory the honour of being the largest achromatic in existence. It was brought to America in 1847, and with it Bond discovered Hyperion, the 8th satellite of Saturn, in September 1848; a few days afterwards, Hyperion was independently discovered by Lassell,

near Liverpool. With this 15-inch Bond also discovered the *crape*, or dark ring of Saturn, on the 11th November 1850; a discovery which was also duplicated in England, Mr. Dawes having observed it independently, before the news arrived in England, on the 29th of November.

For fifteen years the twin 15-inch telescopes of St. Petersburg and Harvard, both made by the same German maker, remained the largest refracting telescopes in existence. It was in America that the next step in advance was made by Alvan Clark, a portrait painter of Cambridgeport near to Harvard, who in 1862 made an excellent 18-inch refractor for the University of Mississippi. With it, before it was quite completed, Alvan Clark discovered the now well known companion of Sirius on the 31st of January 1862. The Civil War troubles having commenced, the telescope was never sent to its southern destination; but it has made its mark in the history of astronomy, for it fortunately fell into the hands of Mr. Burnham. It was purchased by a Chicago millionaire, who installed it in a handsome observatory, which he dedicated to the public in memory of his wife, whose maiden name was Dearborne. With this 18-inch in the Dearborne Observatory, Mr. Burnham discovered nearly a thousand new close double stars.

With the old 15-inch refractor of the Harvard Observatory Bond made his great drawing of the Orion Nebula and his important observations of the comet of 1861. Under Prof. E. C. Pickering's directorship the Harvard Observatory has been considerably enlarged. The work involved by his photometric and spectroscopic surveys of the Heavens requires a considerable addition to the staff of observers and computers. The additional expense involved is provided for by the guarantees of private individuals and voluntary subscriptions, a system which is more likely to be fruitful of beneficial results than the European plan of Government endowment, as it interests a large number of people in the work carried on, and their interest reacts beneficially upon the workers.

ORBIT OF ALGOL.

Some seven or eight years ago Prof. E. C. Pickering showed that there was considerable probability that the variation in the light of Algol was due to the periodical transits of a dark companion across the face of the bright star. He pointed out that the orbit of the bright star in such a system might be determined by spectroscopic observations, even when the distance of the system is not known. At a recent meeting of the Prussian Academy, Prof. Vogel stated that he had obtained six good photographs of the spectrum of Algol, three taken before minimum periods and three after. The three taken previously to the minimum periods show the lines decidedly displaced towards the red end of the spectrum, and the three taken after the minima show a similar displacement towards the blue end as compared with the lines in the solar spectrum. From careful measurements Prof. Vogel makes the motion of approach and recession of the bright star to be about equal and to amount to 27 miles per second. Assuming a circular orbit for the stars in a plane passing through the earth, Prof. Vogel derives the following elements for the system of Algol.

Diameter of Algol	1,074,100	English miles.
Diameter of the dark companion	840,600	,,
Distance of centres	3,269,000	,,
Speed of Algol in its orbit ...	27	,,
Speed of the companion in its orbit	56	,,

He makes the mass of Algol $\frac{4}{9}$ths that of our sun, and the mass of the companion $\frac{2}{9}$ths. This is on the assumption that the density of the two bodies is similar, and that there is a central transit. If the dark body transited above or below the centre of the luminous body, its relative size would be larger.

We regret to announce the death of Prof. Lorenzo Respighi, Director of the Osservatorio Campidoglio, Rome. He died on the 10th of December. By his death astronomy loses a most active worker and acute reasoner.

Notices of Books.

Hampstead Hill: Its Structure, Materials, and Sculpturing. By Prof. J. Logan Lobley, F.G.S. (Roper and Drowley.) Just as the modern student of history finds it necessary to have monographs on special periods, the lover of nature is glad of books dealing with the features of some small district with which he may be familiar. The museum-haunting specialist wants systematic memoirs, including all the species of some one group; but there are many genuine students who will also read with avidity works relating to outdoor natural history, to the geological history of the landscapes they admire, and on the occurrence and distribution through these well-known scenes of favourite plants, birds, or insects. It is to this auditory that Professor Lobley's elegant little book on Hampstead Hill will appeal. Matters topographical and archæological have been perhaps too rigidly excluded. The greater part of the book, that by Professor Lobley himself, is geological. The style is simple, and the geological chapters will be readily comprehended by anyone. It is needless to say, to those who know the writer's long and enthusiastic study of London geology, that they are accurate in detail. It might have been as well to refer to the fact that Professor Prestwich has recently proposed the separation of the sands of Hampstead from the main mass of those in the Bagshot area under the name "London Sands," and in a new edition we trust we may be indulged in a special chapter on the inferences from the Kentish Town Well, the section of which is given without comment on p. 61, and other deep borings, as to the oldest known condition of our London area.

It is, we presume, too late in the day to lament that local natural histories no longer have the irresponsibly gossipy form of White's *Selborne*, Knapp's *Journal of a Naturalist*, or Lees' *Botanical Looker-Out*, but must perforce be pervaded by the lists which rightly occupy so large a space in the *Proceedings* of local societies. In looking through the latter part of the work now under notice, however, we are constantly asking, like Oliver Twist, for more. Mr. Harting's list of the birds of Hampstead has indeed admirable, though brief, notes as to the frequency and mode of occurrence of the several species; but for the flora and insect-fauna, contributed by Dr. Wharton and the Rev. Dr. Walker, we have merely the bare lists.

We could hardly imagine a work speaking of the plants of Hampstead without any reference to Thomas Johnson. His *Ericetum Hamstedianum*, published in 1629, is the second printed account of a botanical excursion in England, and his *Enumeratio plantarum in Ericeto Hampstediano crescentium*, published in 1632, and recording 141 species, is the first local flora printed in this country. Then again Samuel Doody, who knew mosses "best of any man," was buried at Hampstead on December 3, 1706, his funeral sermon being preached by Adam Buddle, himself one of the most accurate of botanists, and one who made Hampstead one of his chief hunting-grounds.

We should be glad to see a complete Natural History of Hampstead. As Dr. Walker, whose lists are given, enumerates *Myriopoda*, *Arachnida*, and *Entomostraca* among the insect-fauna (!), we may direct his attention, and that of Professor Lobley, to a *Note on the Fauna of the Hampstead Ponds*, by B. B. Woodward, Esq., in the *Abstract of Proceedings of the West London Scientific Association* for March, 1876, which gives four amphibians, four fish, and ten mollusks, besides water insects and Crustacea. A few of the land-shells are recorded in Cooper's *Flora Metropolitana*, and assuredly a glance through the *Journal of the Quekett Microscopical Club* will afford a goodly list of micro-organisms.

Local residents—that is, Londoners generally—might do worse than purchase Professor Lobley's book and interleave it for their own additions.—G. S. Boulger.

The River Karun; an Opening to British Commerce. By W. F. Ainsworth, Ph.D., F.S.A., F.R.G.S. (W. H. Allen & Co.) The Karun is the chief river of Persia, and, in fact, from a commercial point of view, the only river of any importance. By a treaty recently concluded with the Shah, it has been opened to navigation, and consequently to British commercial enterprise. Flowing as it does into the head of the Persian Gulf, and connected as it is by canal with the Shat-al-Arab (the stream formed by the junction of the Euphrates and Tigris), it is manifestly a water-way of great importance in the development of the resources of a country which is perhaps as little known to the Western World as any of the great Asiatic empires. Under these circumstances, the publication of Dr. Ainsworth's book is most opportune. Having himself ascended the lower half of the river's course, the author is competent to speak of the capabilities of the route, and, for what his own experience failed to supply, he has liberally availed himself of that of other Persian travellers and explorers. The book consists of three parts, the first supplies very full details of the whole of the navigable course of the river, the towns on its banks, and the facilities they offer respectively as trading stations. The second discusses the question of land communication, a matter of equal importance with the water-way, and one which is apparently beset with great difficulties. The third part deals with the natural products of the country, which are sufficiently varied and valuable to form an attractive prospect for European enterprise. It is gratifying to learn that there has lately been great increase in the trade of the United Kingdom with Persia, the tonnage employed for that purpose in the Persian Gulf having increased in sixteen years from 1,200 to 70,000 tons, and it is to be hoped that the recent treaty may be the means of still further augmenting this total. On the opposite side of the country the trade is of course wholly in the hands of the Russians, who, by their Trans-caucasian railways and the navigation of the Caspian, are in a good position to monopolize the whole of its commerce unless a vigorous competition is started on the only other seaboard. To British capitalists, therefore, the question of the development of trade with Persia is largely one of rivalry with Russia. The country immediately around the Karun is, as Dr. Ainsworth points out, rich in antiquarian interest, and explorations would no doubt yield many interesting results. There seems to be a curious misprint on p. 111, where the river is stated to flow from S.S.W. to N.N.E., instead of in the opposite direction.

A Primer of Sculpture, By E. Roscoe Mullins. (Cassell and Co., London.) This is a charmingly illustrated little book written in a philosophic spirit and interesting to the general reader as well as to the art student who has adopted sculpture as a profession. Mr. Mullins is in favour of the student learning thoroughly the handicraft of his art, and, as soon as he has acquired sufficient dexterity in technique, applying himself to the study of nature and the interpretation of his own time rather than to the endless copying of classical models. Though students of science generally appreciate the great importance of being able to draw the objects they are studying, too few of them as yet recognise the great value which a model possesses in explaining ideas involving three dimensions. Mr. Mullins's book will give them some useful hints for making models in both clay and wax.

Mount Vesuvius: a Descriptive, Historical, and Geological Account of the Volcano and its Surroundings. By J. Logan Lobley, F.G.S. (Roper & Drowley.) Probably no volcanic region has been so long and so well observed as that around Vesuvius. The beautiful situation of the volcano in one of the fairest and most frequented parts of Italy, as well as the frequency and violence of the eruptions, have fixed the attention of mankind on the changes going on in the Bay of Naples. Pliny, Sir William Hamilton, and a long series of careful observers have noted the phenomena of successive eruptions, and speculated upon the causes at work. Prof. Lobley reviews at length the history of the mountain and of the neighbouring volcanic regions, and he gives a striking series of drawings of Vesuvius illustrating the changes which have taken place since the great eruption of A.D. 79, when Pompeii was destroyed. Perhaps the most interesting chapter is that in which Prof. Lobley reviews the various hypotheses of volcanic action which theorists have from time to time maintained—while admitting that active volcanoes are generally situated on the sea-coast, or beside rivers or lakes. He thinks that insuperable difficulties exist in explaining the method by which water can pass from the sea to a deep source of volcanic action, since open fissures would either not allow of water descending in the face of the stream that would force it back, or they would themselves be the channels of emission for the lava, so that volcanoes would be confined to the sea bottom. He dismisses as equally unsatisfactory the theory that water may reach the regions where the melted lava is stored by capillary transmission through rocks, while the lava can only issue by fissures in the rock; but at the same time he admits that immense quantities of steam issue from volcanic vents where lava is poured out, and that salt in considerable quantities is found with the Vesuvian minerals. He rejects the theory that the solid rocks form only a thin skin over a sea of melted lava, and is inclined to believe that there are local regions where the rocks are melted and occasionally reach the surface as lava. He assumes that "the primary cause of the formation of fluid lava is the internal heat of the globe inducing chemical, and possibly electrical, action in subterranean regions where the chemical composition of the rocks and their contained and associated minerals are favourable; and where, moreover, the conditions become more favourable by the removal of the restraining vertical pressure of the superincumbent rock masses, by the counteracting lateral or tangential pressure produced by secular cooling causing shrinkage."

Charts of the Constellations from the North Pole to between 35 and 40 degrees of South Declination. By Arthur Cottam, F.R.A.S. (London: E. Stanford.) This magnificent series of stellar charts certainly forms one of the finest, if not *the* finest delineations of the stars visible to the observer in Central Europe. It is intended primarily for the possessors of telescopes which are not mounted equatorially. The owners of such telescopes have hitherto had

much difficulty in picking up double, red, and variable stars, nebulæ, &c. not visible to the naked eye, owing to the absence of reliable maps by means of which most of them could be readily identified. In the present charts, which meet this long-felt want, nine-tenths of W. Struve's double stars, with a selection from the catalogues of his son and Mr. Burnham, most of the red stars in Mr. Birmingham's catalogue, nearly all the known variables, and a very large number of nebulæ and clusters from the catalogues of Sir William and Sir John Herschel are inserted for the epoch 1890, every star visible to the naked eye in the portion of the heavens charted being also given. We think, however, that, in the case of naked-eye pairs, Struve's, O. Struve's, or Burnham's numbers should have been attached, when the pairs in question were not too close or unequal to have been visible in instruments of moderate dimensions; or at least that some indication of their being double should have been given—as is the case in Proctor's maps, as well as the excellent atlas (too little known to Englishmen), the *Tabulæ Cælestes* of Schurig. The scale is very large, one-third of an inch to a degree of a great circle; and the charts being printed on drawing paper, any new objects can be easily inserted. One distinctive feature of the map is that every constellation—with the single exception of the unmanageable Hydra—is shown complete on a single chart. The charts number in all 36, in which the 57 constellations shown are included. Something of the kind was attempted in England many years ago, but, if we remember rightly, only the constellations of Orion and Lepus were issued, and the scheme eventually fell through. Mr. Cottam very wisely, considering the astonishing discrepancies between the drawings hitherto published, refrains from giving any delineation of the Milky Way. We are glad to hear that it is his intention to bring out a similar series of charts of the Southern Heavens, and we may then hope to see a large increase in the number of observers at the Antipodes.

The Southern Skies. By the late R. A. PROCTOR. (W. H. Allen & Co., London.) This is an atlas nearly uniform with Mr. Proctor's "Half-hours with the Stars," a guide to the Northern Heavens, which has gone through several editions. It contains twelve circular maps, each showing the principal constellations above the Horizon for different periods of the year. Mr. Proctor, who had a special gift for map drawing, had nearly completed this little atlas at the time of his death. An observer, lying on his back in Latitude 38 South, would see the stars at the centre of the maps directly over his head at the hours and dates mentioned, and the different constellations visible in their several places relatively to the horizon. Mr. Proctor points out that the atlas can be made use of for other latitudes than 38° S. by means of a piece of paper cut according to a diagram he gives, so as to cover up a portion of the map and show the stars along the southern horizon. The maps form an excellent introduction to the Southern constellations. An observer who wishes to explore the southern heavens will, after having made himself familiar with the principal stars by means of these maps, have no difficulty in finding smaller stars and nebulæ, by means of star catalogues and the larger star maps.

The Anatomy of the Frog. By A. ECKER, translated, with annotations and additions, by G. HASLAM. 8vo. (Clarendon Press, Oxford. 1889.) Pp. 1–449. Illustrations. The handsome volume before us is the second of a series in course of publication by the Clarendon Press, issued under the title of "Translations of Foreign Biological Memoirs." The letter-press and illustrations are excellent. We would especially call attention to the splendid execution of the two coloured plates illustrating the vascular anatomy of the Frog. The work is called a translation of Ecker's monograph, of which the first part appeared in 1861, and the second in 1882; but it is really a great deal more than this. Thus, the translator states that he has added extensively to the text, and also to the number of the illustrations; while the chapter on the Central Nervous System is entirely re-written, and the one following is re-arranged. The Frog is an animal of wide interest, as belonging to that class in which alone we find actual living examples of evolution; these creatures commencing life in a stage which is, to all intents and purposes, on the platform of the Fishes, while in their perfect state they are but little removed from true Reptiles. The Frog, as our author remarks, has also an adventitious interest, as being the unfortunate animal selected for the doubtful honour ot so many physiological experiments; and it is, therefore, of great importance that its detailed anatomy should be fully and accurately known. The introductory chapter treats of the external contour of Frogs, as exemplified by the Edible Frog and the Common Frog (*Rana temporaria*). It is noticed that two species have been confounded under the latter name; the second one being termed *R. oxyrhinus*, although, according to Mr. Boulenger's British Museum catalogue, its right name is *R. arvalis*. In the first section of the work we have an elaborate description, with some excellent figures, of the bones of the skeleton. It is worthy of notice that the author terms the bony bar of the shoulder-girdle situated in advance of the coracoid the "clavicle," instead of the precoracoid. In this respect he follows Prof. Wiedersheim. Now, the latter writer identifies this so-called clavicle with the bone generally termed precoracoid in the Chelonia, which he likewise identifies with the clavicle. If, however, the epiplastrals of the Chelonian plastron are rightly regarded as the clavicles, it is quite clear that the deeper-seated pair of bones cannot also be clavicles; and since the latter bones are almost certainly the same as the so-called clavicles of the Frog, it seems to us that these two bones should be regarded both in the Chelonia and the Frog, as the precoracoids. We may direct attention to the curious sexual difference in the humerus of the Frog, so well shown in the illustration on page 41—a difference which is still more strongly marked in the South American genus, *Leptodactylus*. In calling the conjoint bones of the fore-arm "radio-ulnar" (p. 43), the translator evidently should have written radio-ulna, as he speaks of tibio-fibula on page 47. The following seven sections are devoted to the description and illustration of the soft parts, into the details of which we are prevented by want of space from entering. That this work is worthy to take rank with Straus-Durckheim's *Anatomy of the Cat*, and Prof. Mivart's later treatise on the same subject, we have no hesitation in saying. We regret, however, to find that no mention whatever is made of the Tadpole, and of the wonderful metamorphosis of the latter into the perfect Frog; and we think that the translator might well have added a chapter on this subject, and have shown us how the organisation of the larva is gradually modified into that of the adult. We may, however, venture to hope that this omission will be remedied in a future edition.

Index of British Plants, according to the London Catalogue (Eighth Edition). By R. TURNBULL. London. 1889. Pp. 1–98. 8vo. The popularity of this little work is sufficiently evidenced by its having reached its eighth edition. Such a guide will be found of considerable assistance to amateur botanists, in wading through the complex nomenclature with which this branch of natural science is weighted. Full reference to descriptions and figures are given, which, if accurate, must be of great

value. Whether, however, the plan of indicating the accentuation of technical names by diacritical marks and division into syllables is altogether an advisable one we are not fully assured.

Flower-Land: an Introduction to Botany. By Robert Fisher, M.A. (Bemrose & Sons.) This is an enlargement of a book which the author issued last year under the same name, and which met with a sufficiently favourable reception to tempt him to add to it a second and more advanced part. The present volume gives an excellent outline of Phanerogamic Botany in the simplest possible style and language. The technicalities which usually form so deterrent a feature in a first book on botany are, in the introductory part, smoothed over in a wonderful way, and the reader is only gradually introduced to a fuller terminology. The book is profusely illustrated with excellent cuts, and there is a constant appeal to nature, and to actual specimens to be hunted up from hedges, woods, and fields, that tends to check the acquisition of mere book-knowledge, and puts the tyro on the right path to become a practical and scientific botanist, should his inclinations travel in that direction. Young beginners in botany could not start with a better equipment than Mr. Fisher's "Flower-Land."

On the Causes, Treatment, and Cure of Stammering. By A. G. Bernard, M.R.C.S., L.R.C.P. (J. & A. Churchill). According to the author, at least one in every thousand of the population of this country is a stammerer, but he is convinced that this proportion is needlessly great, and that persons so afflicted have in their own hands the power of cure. He was once an inveterate stammerer himself, but cured himself by the system he advocates in this manual. There are rules to be observed and exercises consisting of literary extracts and sets of words difficult of pronunciation to be repeated. Patience, perseverance, strict adherence to the rules, and careful practice of the exercises will, Mr. Bernard believes, produce in those suffering from this unpleasant defect proper control of the vocal organs, and enable them to speak without discomfort to themselves or their auditors.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

BARNARD'S COMET (1884. II.).

To the Editor of Knowledge.

Sir,—In case anyone should think I ought to have included this comet amongst those "due in 1890," perhaps I may be allowed to point out the hopelessness of seeing it at the forthcoming return. Herr A. Berberich has published in the *Astronomische Nachrichten*, Nos. 2938-9, a very elaborate determination of its orbit, and finds that a perihelion passage will be due on the 10th of next month (January 1890); but he adds that the longitude of the perihelion is 306°, whilst that of the sun at the time will be 290°, and that the comet's angular distance from the sun, as seen from the earth, will scarcely exceed 9° during several months. At the following return, in the month of May 1895, the conditions of visibility will be somewhat more favourable. The author of the "Astronomical Column" in *Nature* for October 2, 1884, pointed out that this comet must have made a near approach to the planet Mars in the month of April 1868; this may of course have somewhat altered the period, and possibly it may after all be found that the comet is identical with De Vico's periodical comet of 1844, and with La Hire's comet of 1678, determined by Le Verrier to be elliptic and of short period.

Yours faithfully,

Blackheath, Dec. 11. W. T. Lynn.

P.S.—It has been pointed out to me that I overlooked, in my article, the investigation of the orbit of Mr. Denning's comet, which was published by Dr. B. Matthiessen of Carlsruhe, in *Ast. Nachr.*, No. 2903. Availing himself of an observation made at Strasburg on the 24th of November 1881, five days later than any previously published and used in the calculation, he found the probable period to be a little shorter than Mr. W. E. Plummer had done, and to amount to about 8·69 years, which would bring the comet to perihelion again in the month of May 1890, though the theoretical brilliancy will then be less than a third part of what it was when the comet was discovered by Mr. Denning in October 1881.

WILSON'S THEORY OF SUNSPOTS.

To the Editor of Knowledge.

Sir,—It is with great diffidence that I venture to express an opinion somewhat adverse to the statement of such a well-known observer of solar phenomena as the Rev. Mr. Howlett, which is contained in his letter published in the September number of Knowledge, and is to the effect that the Wilsonian theory of spots being depressions in the atmosphere is wrong. Certainly, on looking over several drawings of sunspots that I have from time to time made, my sketches of spots near the limb do not bear out Wilson's idea. I find, in fact, that no hard and fast line can be drawn respecting the appearance of a spot at the edge of the disc. One spot, for instance, which I observed not far from the E. limb, on July 9, 1881, had the penumbra arranged symmetrically round it during its progress across the sun's surface until July 17th, on which date it was about as far from the W. limb as it was from the E. limb when first seen. Its appearance now confirmed Wilson's theory, for much more of the penumbra was visible on the *following* side of the nucleus than on the *preceding* side. From this instance, which I might illustrate with one or two others, it appears to me that, just as Carrington was of opinion that there were two kinds of solar spots, "those which notably change their place on the sun's surface, and those which remain constantly at the same place," so we must conclude that there are spots considerably depressed below the level of the sun's surface, as well as those (perhaps the larger number) which are but slightly, if at all, depressed below the surface. It would be interesting to note whether the spectroscope reveals any difference in the nature of the spots that could be accounted for on the supposition that they differ in depth.—Yours faithfully,

Forest Gate, E. B. J. Hopkins.

[The spots so frequently change in form as they pass across the disc, that one must not assume too readily that all changes of form on approaching the limb are due to perspective.—Ed.]

THE FACE OF THE SKY FOR JANUARY.

By Herbert Sadler, F.R.A.S.

WHENEVER the state of the sky during the past month has permitted the sun's disc being observed, the spots seen have been both few in number and small in size. Conveniently observable minima of Algol (*cf.* "Face of the Sky" for December 1888) occur at 9h. 48m. p.m. on the 3rd; 6h 37m. p.m. on the 6th; 11h.

30m. p.m. on the 23rd; 8h. 18m. p.m. on the 26th; and 5h. 7m. p.m. on the 29th. Minima of Lambda Tauri (*cf.* "Face of the Sky" for December 1888) take place at 11h. 0m. p.m. on the 3rd; 9h. 52m. p.m. on the 7th; 8h. 14m. p.m. on the 11th; 7h. 36m. p.m. on the 15th; 6h. 29m. p.m. on the 19th; 5h. 20m. p.m. on the 23rd; and 4h. 13m. p.m. on the 27th. The beautiful red star R Leonis (*cf.* "Face of the Sky" for March 1888) attains a maximum on the 30th. Mercury is visible as an evening star during the greater portion of the month, but is in a bad position for observation owing to his southern declination. On the 1st he sets at 5h. 1m. p.m., 1h. 1m. after the sun, with an apparent diameter of 5¼″, and a southern declination of 23° 9′. He is at his greatest eastern elongation (18° 51′) at 3h. a.m. on the 14th. On the 21st he sets at 5h. 58m. p.m., 1h. 30m after the sun, with an apparent diameter of 8½″, and a southern declination of 14½°. At 6h. p.m. on the 29th he is in inferior conjunction with the sun. During the month he passes from Sagittarius into Capricornus. On the evening of the 4th he will be near the 6th magitude star 4 Capricorni; at 3h. p.m. on the 13th he will be about 1½′ *s.p.* the 4th magnitude star θ Capricorni. On this evening he sets at 5h. 58m. p.m. Venus is practically invisible. Mars is a morning star, rising on the 1st at 1h. 57m. a.m., with an apparent diameter of 6½″, and a southern declination of 10¼°. On the 31st he rises at 1h. 30m. a.m. with an apparent diameter of 8″·0, and a southern declination of 15½°. During the month he passes from Virgo into Libra, but does not approach any naked-eye star very closely. Vesta is in opposition to the sun on January 18th, when she rises at 4h. 24m. p.m., with a northern declination of 23½°, and is then distant rather less than 140 millions of miles from us. Vesta will appear at this opposition as a 6½ magnitude star, and is considered to be the largest of the minor planets. From photometrical determinations, Stone made the diameter of this minor planet 214 miles, Argelander 270, Pickering 319. By measurement of the disc Schröeter made the diameter 430 miles, Mädler 300, Tacchini (at the very favourable opposition of 1880, when he used a power of 1000 on the refractor at Palermo) 880 miles. Secchi, comparing it with the first satellite of Jupiter, estimated the diameter at 450 miles, and "*di colore ranciata carico.*" Vesta is situated a little to the N.W. of Præsepe at the beginning of the month, and describes a retrograde path through Cancer to the confines of Gemini. Jupiter is in conjunction with the sun on the 10th. Saturn is in a very favourable position for observation, rising on the 1st of the month at 8h. 33m. p.m. with an apparent diameter of 19″, and a northern declination of 11° 39′ (the major axis of the ring-system being 43½″, and the minor 6¼″ in diameter). On the 31st he rises at 6h. 25m. p.m., with a northern declination of 12° 21′, and an apparent diameter of 19½″ (the major axis of the ring-system being 45″, and the minor 7″ in diameter). On the evening of January 3rd Titan will be about 30″ *n.* a little *p.* the planet, and Iapetus will be at his greatest western elongation, at which time he is at his brightest. At about 11h. 30m. p.m. on the 11th Titan will be 29″ south of the planet, and on the evening of the 19th about 32″ *n.* a little *p.* At 8h. p.m. on the 21st Iapetus will be 19″ north of Saturn. At 11h. p.m. on the 22nd Rhea and Iapetus will apparently form one object. At 9h. 30m. p.m. on the 27th Titan will be 31″ south of Saturn. As Uranus does not rise till 20m. before midnight on the last day of the month, we defer an ephemeris of him till February. Neptune is still in a very favourable position for observation, rising on the 1st at 1h. 29m. p.m. with an apparent diameter of 2½″, and a northern declination of 18° 58′. On the 31st he rises at 11h. 26m. a.m. He describes a very short path to the S.E. of 43 Tauri. January is a favourable month for the observation of shooting stars, the most important shower being the *Quadrantids*, the radiant point being in R.A. 15h. 12m., and 53° north declination, the greatest display being visible during the morning hours of January 1-3. The moon will be full at 5h. 37m. a.m. on the 6th, enters her last quarter at 6h. 33m. a.m. on the 14th, is new at 11h. 49m. p.m. on the 20th, and enters her first quarter at 8h. 16m. p.m. on the 29th. On the 2nd, at 11h. 3m. p.m., the 3½ magnitude star ϵ Tauri will disappear at an angle of 178° from the vertex, and reappear at 11h. 57m. p.m. at an angle of 271°. On the 3rd the 5½ magnitude star *l* (106) Tauri will disappear at 4h. 5m. p.m. at an angle of 13° from the vertex, and reappear at 4h. 40m. at an angle of 299°. At 4h. 12m. a.m. on the 4th the 6th magnitude star 114 Tauri will make a near approach to the lunar limb at an angle of 224°. At 5h. 20m. p.m. the same evening the 6th magnitude star 141 Tauri will disappear at an angle of 60° from the vertex, and reappear at 6h. 22m. at an angle of 242°; the 6th magnitude star 6 Geminorum disappearing at 11h. 35m. p.m. at an angle of 120°, and reappearing at 0h. 54m. a.m. the next morning at an angle of 286°. At 1h. 49m. on the morning of the 5th the 3½ magnitude star η Geminorum will make a near approach to the lunar limb at an angle of 37°; and at 5h. 54m. a.m. the same day the 3rd magnitude star μ Geminorum will disappear at an angle of 49° from the vertex, and reappear twelve minutes later at an angle of 23°. At 9h. 26m. p.m. on the 6th the 6½ magnitude star 84 Geminorum will disappear at an angle of 28°, and reappear at 10h. 39m. p.m. at an angle of 257°. At 4h. 16m. a.m. on the 7th the 6½ magnitude star 7 Cancri will disappear at an angle of 135°, and reappear at 5h. 19m. a.m. at an angle of 279°. At 6h. 34m. the same morning the 5½ magnitude star μ^2 Cancri will disappear at an angle of 75°, and reappear at 7h. 16m. at an angle of 340°. At 2h. 3m. a.m. on the 14th the 6th magnitude star 80 Virginis will disappear at an angle of 341°, and reappear at 2h. 48m. a.m. at an angle of 259° from the vertex. At 3h. 34m. a.m. on the 16th the 6th magnitude star o^1 Libræ will disappear at an angle of 3° from the vertex, and reappear at 4h. 30m. a.m. at an angle of 244°. At 6h. 24m. a.m. on the 17th the 5th magnitude star ψ Ophiuchi will disappear at an angle of 53°, and reappear at an angle of 234° at 7h. 35m. a.m. At 6h. 39m p.m. on the 24th the 5th magnitude star 30 Piscium will disappear at an angle of 152°, and reappear at 7h. 42m. at an angle of 328°; and the 5th magnitude star 33 Piscium will disappear the same evening at 8h 24m. p.m. at an angle of 131°, and reappear, the moon having set at the time, at 9h. 17m. p.m. at an angle of 356°. At 6h. 28m p.m. on the 29th the 6th magnitude star B.A.C. 1272 Tauri will make a near approach to the lunar disc at an angle of 8° from the vertex.

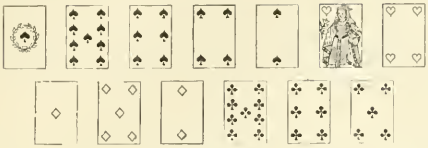
Whist Column.

By W. Montagu Gattie.

DISCARDING INSTEAD OF TRUMPING.

It is frequently advantageous to abstain from trumping a losing trick when a good discard can be made by passing it, or when it is not desirable to obtain the lead, or when the suit is one which partner wishes to clear. All these conditions are fulfilled in the following hand, which is taken from actual play.

Hand No. 8.



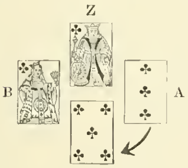
Y's Hand.

Score—Three all. Z turns up the ten of spades.

Note.—A and B are partners against Y and Z. A has the first lead; Z is the dealer. The card of the leader to each trick is indicated by an arrow.

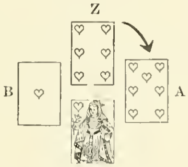
The notes appended to the tricks are supposed to be made during the play by the player whose hand is exposed. The subsequent remarks relate to the play generally.

Trick 1.



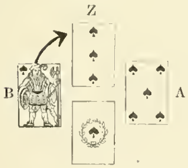
Tricks—AB, 0; YZ, 1.

Trick 2.



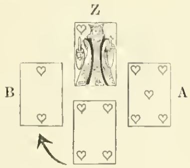
Tricks—AB, 1; YZ, 1.

Trick 3.



Tricks—AB, 1; YZ, 2.

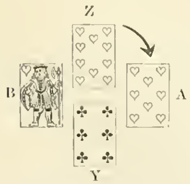
Trick 4.



Tricks—AB, 1; YZ, 3.

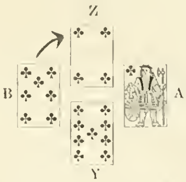
Note.—*Trick* 3.—It is already probable that AB have three honours between them, and therefore will win the game unless YZ can make two by cards. For B's lead must be either from five trumps to the knave, queen, king, or from weakness; so that, if Z had held queen or king, he would have known the knave to be a strengthening card led from weakness, and, with less than four trumps, would probably have covered it—especially as he holds the ten.

Trick 5.



Tricks—AB, 2; YZ, 3.

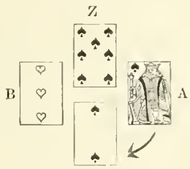
Trick 6.



Tricks—AB, 3; YZ, 3.

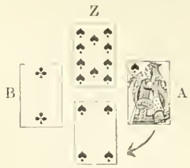
Note.—*Trick* 5.—Y wishes to retain his strength in trumps and also to avoid having the lead, which would necessitate his opening the diamonds. By passing the losing heart he enables his partner to clear that suit, and at the same time rids himself of a small card of the adversaries' suit. It will be seen presently that any other play should lose the game

Trick 7.



Tricks—AB, 4; YZ 3.

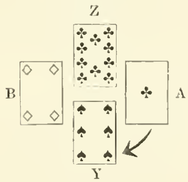
Trick 8.



Tricks—AB, 5; YZ, 3.

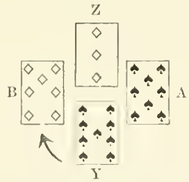
Notes.—*Tricks* 7 and 8.—Z has the long heart, A has the eight of trumps, and B's remaining cards are all diamonds (B cannot have another club, for he returned the seven at trick 6, and now plays the deuce).

Trick 9.



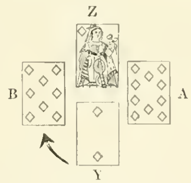
Tricks—AB, 5; YZ, 4.

Trick 10.



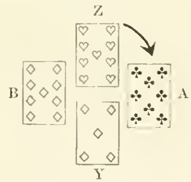
Tricks—AB, 5; YZ, 5.

Trick 11.



Tricks—AB, 5; YZ, 6.

Trick 12.



Tricks—AB, 5; YZ, 7.

Note.—*Trick* 11.—Z has the long heart and two diamonds; A has the long club and two diamonds; B has three diamonds. If Z has the king of diamonds, YZ win the game anyhow; but otherwise, they even lose the odd trick if Y leads ace and then a small one; for if B has the king, he will afterwards make the last diamond and, if A has the king, he will afterwards make his club. Y therefore leads a small diamond.

Trick 13.—Y makes the ace of diamonds, and

YZ win two by Cards and the Game.

A's Hand.	B's Hand.
S.—Kg, Qn, 8, 5.	S.—Kn.
H.—8, 7, 5.	H.—Ace, Kn, 3, 2.
C.—Ace, Kn, 8, 3.	C.—Qn, 7, 2.
D.—Kn, 10.	D.—Kg, 9, 8, 7, 4.

Y's Hand.	Z's Hand.
S.—Ace, 9, 6, 4, 2.	S.—10, 7, 3.
H.—Qn, 4.	H.—Kg, 10, 9, 6.
C.—9, 6, 5.	C.—Kg, 10, 4.
D.—Ace, 5, 2.	D.—Qn, 6, 3.

Remarks.—*Trick* 3.—B no doubt thought himself fairly safe in every suit; but there seems no justification for the

trump lead. If he had opened his diamonds in the ordinary way, AB must have won the game and would probably have obtained the odd trick.

Trick 4.—Z dare not finesse, for he does not know that B's lead to trick 3 was not from great strength in trumps.

Trick 5.—If Y trumps here, he must continue with a diamond. Supposing him to lead a small one (the most favourable case), Z, after winning with the queen, could do no better than give him another force in hearts, and the only other card YZ could make would be the ace of diamonds, which would only give them the odd trick.

Trick 6.—At this point, B plays correctly, we think, in returning the club suit instead of opening the diamonds, as it is desirable to throw the lead into A's hand.

Trick 9.—But here A, in his turn, throws away the game. B can have nothing but diamonds, and the knave would almost certainly be a very useful card to him. It would clearly have been better to lead through Y than to let him lead through B. As the cards actually lay, a diamond lead must have won the game for AB; for, even if Y had held up the ace and B had finessed, Z on getting in with the queen could have done no better than to lead the long heart; A would have trumped of course, and Y, after over-ruffing, would have had no opportunity of ridding himself of his small diamond.

ELEMENTARY EXPLANATION OF THE PLAY.

Trick 1.—A opens his strongest suit. The card led being a small one, it is clear that he is not leading from a weak suit of three or less, in which case he would have led the highest. Consequently all the players infer that A has at least four clubs.

Trick 2.—Similarly, all the players now infer that Z has at least four hearts, of which three are better than the six. A plays the seven instead of the five, to save his partner's hand, in case Y should prove very weak in the suit. This is not intended as a call for trumps, but it is so likely to be taken in that sense that it is rarely safe to play so low a covering card as the seven unless fairly strong in trumps. As A holds four trumps to two honours, he is justified in running the risk that B may think he has "called."

Trick 3.—B has good diamonds, and the second-best heart twice guarded, and his partner has shown strength in clubs. He therefore leads his single trump. But he would, no doubt, have done better to open his long suit.

Trick 4.—Y returns his partner's lead. It is clear to him from this trick that the knave of hearts is with A or B, for if Z had held it he would have played it instead of the king, in accordance with the rule that a trick should always be won with the lower of two indifferent cards.

Trick 5.—Y discards a club, in preference to trumping the trick. The student should observe that nothing is lost by this; for Y at the same time disposes of a losing card in A's strong suit. If Y had trumped, B would have held up his knave, and Z's suit would not have been cleared.

Trick 6.—B returns his partner's lead with the higher of two remaining. A, in accordance with the rule just explained, wins with the knave. The ace is now marked in his hand; whereas, if he had played the ace, no one at the table could have told where the knave was.

Tricks 7 *and* 8.—A responds to his partner's trump lead by drawing two rounds. B's discards show that his other cards are all diamonds. For Z must have the remaining heart (see note to Trick 2); and, as B, after returning the seven of clubs (Trick 6), now plays the deuce, he can only have held three originally. Unless Z's ten of spades is a false card (which is not likely), it is now clear to A that Y holds the nine and the six, while Y, on his part, can place the eight with A.

Trick 9.—A leads the club to force a trump from Y; but, as it is certain that Y, after drawing the eight of trumps, will lead diamonds through B, it would have been much better to open the diamond suit at once with the knave, so as to assist B as much as possible. The remainder of the play is fully explained in the note appended to Trick 11.

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*Whist** is the brief but sufficient title of a neat little book by Dr. Pole, which has just been reprinted from the new edition of Bohn's *Handbook of Games*. It aims at giving a *résumé* of the leading maxims of play laid down by Hoyle, Payne, Mathews, Clay, and "Cavendish," together with illustrations of their application, selected from the treatises of the same authors and of General Drayson. The idea of bringing into a single volume all that is best worth preserving in the earlier works, together with a description of the more exact methods of modern times, is in itself an excellent one; and the experience and ability of the compiler are a guarantee that it has been carried out with care and discrimination. It is well known that Dr. Pole is a disciple of the "modern school"; but he wisely refrains from discussing at any length, or unduly insisting upon, its peculiar dogmas, and the "plain-suit-echo" is not even mentioned. The book, in fact, is addressed to learners, and in that light we proceed to criticise it.

The means of conveying information are divided into four classes—namely, "ordinary rules," "uniformity of play," "irregular play," and "conventions"; but the principles on which the distinctions are drawn are not always quite clear. Why, for instance, should the play of king, third in hand, when holding ace also, be assigned to the first class, and the play of four, from both four and five, to the second? Surely both cases are examples of the general convention that the lower of two indifferent cards should always be played by everyone except the leader. The signal for trumps and the American leads are classed as "conventions." It might be contended that every rule of play is a convention; but, since other headings are given, we should certainly have expected the signal for trumps to appear under "irregular play," and the American leads under "uniformity of play." The signal for trumps consists essentially in the play of a false card, and can only be justified in theory as an unlimited extension of an obvious artifice for deceiving the adversaries. The American leads, on the other hand, are usually supported on the ground that they substitute a uniform and scientific code for a number of previously isolated dogmas. It is difficult, again, to understand why the natural lead of queen from a tierce major in trumps should be described as irregular play, while the inference that the leader of a king in plain suits has also either ace, or queen, or both, is set down among the ordinary rules, and the lead of ace before king from those two cards alone is included with the "conventions."

The maxims are arranged in the chronological order of the books from which they are taken; but it would, we think, have been better, in the interests of the student, to group them systematically. There is a risk of his becoming confused, or at least wearied, in the endeavour to master a number of miscellaneous precepts between which there is no apparent cohesion. He may also be perplexed, in the absence of any explanation, at seeming inconsistencies in the advice offered. Thus, on page 59, Dr. Pole quotes from Clay as follows:—"Do not play false cards. The habit, to which there are many temptations, of trying to deceive your adversaries as to the state of your

* *Whist*. By Dr. W. Pole, F.R.S. London: George Bell & Sons. 1889.

hand, deceives your partner as well and destroys his confidence in you. A golden maxim for whist is, that it is of more importance to inform your partner than to deceive your adversary. The best whist player is he who plays the game in the simplest and most intelligible way. I hold in abhorrence playing false cards. . . . You have ace and king of a suit, and you take the trick with your ace. This is probably in your adversary's suit, for you would hardly think it right to deceive me in my own; but you cannot resist the temptation of taking in your opponent. What is it you have done? You have told me, as plainly as whist language can speak, that you do not hold the king. . . . Perhaps I fear to lead trumps, because I believe that the suit in question is wholly in the possession of my adversaries. I should have led them if I had thought it possible that you could protect me in that suit. Or it may be that I am sorely put to it to find one trick in your hand with which to save the game. Be sure that the last suit in which I shall look for it will be that in which you have told me that you were unable to resist say a knave or a ten at a cheaper price than your ace. Again, believing that the king is held by my opponents, and being probably able to say in which of their hands it ought to be, I miscount the numerical strength of all the players in all the suits, until at last I find that my partner has paid me the ill compliment of believing that I am likely to play as well with my eyes shut as open."

All this is excellently put. But, a few pages further on, we find a very different doctrine quoted from Hoyle. "If," says that authority, "your right-hand adversary lead from a suit of which you have ace, king, queen, or ace, king, knave, put on the ace, because this will encourage them to play the suit again. It is true you deceive your partner by this method, but it is of more consequence here to deceive your adversaries. If you play the lower one they will discover that the strength of the suit is against them, and will change the suit." What, then, is the student to conclude from these contradictory arguments? The explanation is really contained in a terse maxim of Mathews', which appears on another page. "Play as clear a game as possible when your partner has a good hand. But, when the winning cards lie between you and your adversaries, you may play an obscure game." It is too much to expect a beginner to sort in his mind kindred precepts appearing in different places, and to discover for himself how their discrepancies may be reconciled.

Some of the maxims seem to need qualification, as, for instance, this one from Hoyle:—"If you hold two small trumps only, with ace and king of two other suits, and a deficiency of the fourth suit, make as many tricks as you can immediately." Hoyle's rules for unblocking a partner's suit also require some revision; and further illustrations of the importance of unblocking might with advantage have been added to the "special examples of play." These examples form the most interesting and useful feature of the book. The following is given by Mathews from actual play.

The parties each wanted only the odd trick to win the game. A, the leader, had won six tricks, and remained with knave and one small trump and two diamonds. Y, his left-hand adversary, had queen and ten of trumps, and two clubs. B, A's partner, had two small trumps and two diamonds. Z, last player, had ace and one small trump, one club, and one heart. A led a diamond, which, being passed by Y, was to be won by Z. But Z had to consider that, unless he made every trick, he would lose the game. And he saw that, unless Y had either the two best trumps, or the first and third with a successful finesse, this was not possible. He therefore trumped with the ace, led the small one, and won the game.

We have only space for one other specimen, which is taken from General Drayson's treatise. Nine tricks had been played, and the trumps were all out. Hearts had not been led or thrown. A and B wanted all the remaining tricks to save the game. A (fourth player) held ace, king, knave, and two of hearts. B (his partner) had shown that he held two long clubs, and two hearts unknown. Y (A's left-hand adversary) led a small heart; B played the seven; Z played the ten. A reasoned that after he had won the first trick, unless B could be given the lead in the next trick, so as to bring in his two long clubs, the game must be lost, as his two of hearts must ultimately be taken by one of the adversaries. As the only way of accomplishing this, he took the ten with the ace, and led the two, hoping B might win it with the queen. As it happened, Y had the queen; but, supposing B had the king, he played a small one, when B won the trick with the nine, and saved the game.

A useful glossary of terms used in whist concludes the book; and altogether, in spite of the defects of arrangement to which we have alluded, whist-players of all classes who expend a shilling in purchasing it will certainly obtain full value for their money.

Chess Column.

By W. Montagu Gattie.*

[Contributions of general interest to chess-players are invited. Mr. Gunsberg will be pleased to give his opinion on any matter submitted for his decision.]

Our opinion is asked by Mr M. N. Kuka, of Bombay, on the following interesting and, so far as we are aware, entirely novel variations.

In the King's Knight's opening, after—

White.	Black.
1. P to K4	1. P to K4
2. Kt to KB3	2. Kt to QB3
3. B to B4	

Black has, according to the books, the choice of three moves, viz. 3 . . . B to B4 (the Ginoco Piano), 3. Kt to B3 (the Two Knights' Defence), and 3 . . . B to K2 (the Hungarian Defence). Mr. Kuka proposes, instead of any of these—

	3. Kt. to Q5

And continues the game as follows:—

4. Kt × P	4. P to Q4
5. B × P, or (A)	5. Q to Kt4
6. Kt × P	6. Q × KtP
7. R to Bsq	7. B to Kt5, or (B)
8. P to KB3	8. B to K2, and wins.

Variation A.

5. P × P	5. Q to Kt4
6. Castles	6. B to R6
7. P to Kt3	7. Q × Kt
8. R to Ksq	8. Kt to B6 (ch), and wins.

Variation B.

	7. B to R6
8. B to B4	8. Q × KP
9. B to K2	9. Kt × QBP (ch), and wins.

(Black's last move in Variation B is obviously a slip, for 9 . . . Kt to B6 mates at once.)

Mr Kuka rightly observes that White's best course at move 6 is to play P to QB3, and he thinks that this move should win if followed by 7. Q to R4 (ch). He remarks, also, that White does not seem to gain any substantial advantage by playing Kt × Kt or Castles at move 4; but it may be pointed out that, in the former case, the position becomes similar to that resulting from Bird's defence to the Ruy Lopez, with the difference that the White Bishop is better posted at B4 than at Kt5.

* Mr. Montagu Gattie has kindly undertaken the chess column while Mr. Gunsberg is in Havannah, where he has gone to play a match with the celebrated Russian player, M. Tschigorin.—Editor.

Another good continuation for White at move 4, if he is not inclined to run the risk of taking the King's Pawn, is P to B3, which leaves Black no other course than to exchange Knights, after which White, retaking with the Queen, will be slightly ahead in the development. Let us assume, however, that he has captured the King's Pawn, and that, after taking the Queen's Pawn with his Bishop (clearly the best move), he plays 6. P to QB3. Black may now take either the Knight or the Knight's Pawn with his Queen.

In the first place:—

6. P to QB3	6. Q × Kt

In this case, it is very doubtful whether White should give the check. For example:—

7. Q to R4 (ch)	7. P to B3 (best)
8. P × Kt	8. Q to Q3

Better than 8 . . . Q to B2, which would be met by 9. Q to B2.

9. Kt to B3

If 9. B to Kt3, then 9 . . . P to QKt4. 10. Q to R5, Q × P, and White has an uncomfortable game.

	9. P to QKt4
10. Q to R5 (apparently best)	10. P × B
11. Kt × KtP	11. Q to B3
12. P × P	12. Q to Kt2

And, although White has the advantage, it will not be easy for him to win with his ragged Pawns.

On the other hand, by playing—

7. P × Kt	7. Q × P
8. Q to Kt3	

he at once obtains a decisive superiority If now 8 . . B to K3, then 9. B × B, Q × P (ch), 10. K to Qsq., &c.

In the second place:—

6. P to QB3	6. Q × KtP
7. Q to R4 (ch)	7. P to B3 (best).

BLACK.

WHITE.

In this position White's best course seems to be

8. B × P (ch)	8. K to K2
9. Q to Kt4 (ch)	9. K to B3
10. Q × Kt	10. Q × R (ch)
11. K to K2	

Black has now the choice of several moves, of which 11. . . . B to Kt5 (ch) and 11 . . . Kt to R3 look the most promising; but in any case White appears to have a winning advantage.

Returning to the position on the diagram, and supposing White to play

8. P × Kt,

we believe Black may reply by 8 . . . B to Q2, with a fair prospect of making good his defence; but if he captures the Queen's Bishop, he will lose in a few moves; *e.g.*

	8. Q × B
9. Kt to Q B3	9. Q × R
10. B × P (ch)	10. K to Qsq
11. Q to R5 (ch)	11. P to Kt3
12. Kt × P (ch)	12. K to B2
13. Q to K 5 (ch). &c.	

Mr. Kuka has developed the same idea as a variation of the Vienna game, the opening moves being

WHITE.	BLACK.
1. P to K4	1. P to K4
2. Kt to QB 3	2. Kt to KB3
3. B to B4	3. B to B4

Of course, the same position is arrived at in a variation of the Berlin Defence to the King's Bishop Opening. Mr. Kuka now proposes

4. Kt to Q5

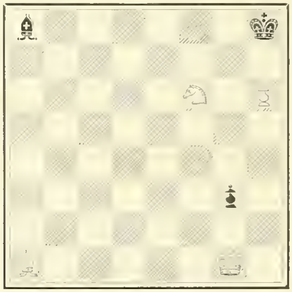
We think that this move may be met by P to QB3 even more advantageously than before, as the adverse bishop is not so well posted at QB4 as on his own square. But, to continue the variation as suggested by Mr. Kuka, let Black play

	4. Kt × P
5. P to Q4	5. B × P
6. Q to Kt4	6. P to QB3
7. Q × KtP	7. P × Kt
8. Q × R (ch)	8. K to K2
9. Q × Q (ch)	9. K × Q
10. B × P	10. Kt × P
11. Kt to B3	11. Kt × R
12. Kt × B	12. P × Kt
13. B × BP	13. K to K2 (?)
14. B to Kt8	14. P to KR4
15. B to Kt5 (ch)	

and Mr. Kuka remarks that White wins, "because the Black Knight cannot escape, and the other black pieces are still at home." But, if instead of Black's 13th move, which we have marked with a query, he play 13 . . . P to Q3, it is difficult to see how White is to obtain any advantage. 14. B to Kt5 (ch) and 15. B to R4 seem to be necessary moves in order to secure the Knight, and Black, after playing his King to B2, may continue with B to B4 and Kt to B3, having by no means a bad game. This result, however, does not detract from the credit due to Mr. Kuka for his original and interesting suggestions.

The following is an amusing end-game puzzle:—

BLACK.



WHITE.

White to play. In how many moves can he force a mate?

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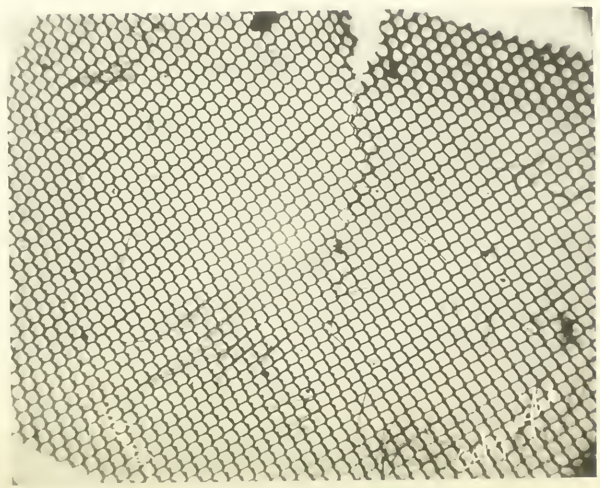
Showing hard parts only. The club-shaped organs at the base are the Maxillary Palpi, proceeding from two cross-bars representing the Maxillæ. The heart-shaped piece consists of two fleshy lobes, each containing about 30 sucking grooves. When not in use, the lobes would be closed upon one another, but are here shown open to display their structure. Magnified about 40 diameters.

Portion of one Lobe of Extremity of Tongue of Fly.

Showing chitinous curved rods in the sucking grooves, with their projecting ends giving a saw-like appearance to the edges of the grooves. Some forked teeth are seen at the base of the grooves. Magnified about 150 diameters.

Portion of Fly's Foot.

Showing last four tarsal joints, terminal claws, and adhesive pads. Photographed from above. Magnified about 50 diameters.



... n of Cornea of Fly's Compound Eye.

Showing about 1600 facets, which are hexagonal in the centre, but become nearly square towards the lower edge. Only the transparent outer layer of the eye is here shown, but each facet has ... eneath it, in the natural condition, all the apparatus necessary to ... produce vision. A few hairs are seen growing from between the facets.

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HOUSE-FLIES AND BLUEBOTTLES.—II.

By E. A. Butler.

As all five of the flies mentioned in our last paper belong to a single family, the *Muscidæ*, they exemplify the same structural type, and, except in a few matters of detail, one may be taken as representing all. To illustrate the main points in a fly's structure, therefore, we will select the bluebottle or blow-fly (*Calliphora*), as it is the largest of the indoor species, and can always be easily obtained. We will suppose that we have before us one of these flies, which has been killed without crushing or otherwise damaging the body; this can be done by means of the fumes of chloroform, cyanide of potassium, or crushed laurel leaves, any of which will in a few moments render such an insect insensible, while a longer exposure to the poisonous vapours will kill it entirely, and leave it in a good condition for examination.

The distinguishing feature of the order is at once noticed in the single pair of membranous wings placed horizontally over the back when at rest, and extended at right angles to the body when in use. As the Diptera are the only order of insects in which a single pair of wings is normally present, there is very little difficulty in distinguishing them, and there are very few other insects that can possibly be mistaken for them. Each wing consists of a thin double membrane, strengthened by six longitudinal hollow ribs or "nervures," of which the larger contain breathing tubes (tracheæ) and nerves. The nervures are not scattered at random, but always, as in other orders, follow a definite course, which varies somewhat in different genera or even species, but is constant in the same, and the general plan is sufficiently definite to permit of the individual nervures being identified and named, so as to be used as aids in classification. A comparison of the accompanying drawing of a bluebottle's wing (Fig. 2) with

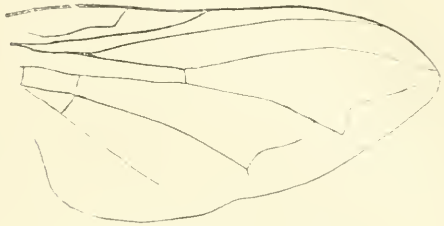


Fig. 2.—Wing of Bluebottle (*Calliphora*).

those of the larger and smaller house-flies given in our last number, will further show what sort of differences may be expected in this respect. The present plan is very much like that of the house-fly proper, and the chief difference is in the præbrachial nervure (the third on the disc of the wing towards the tip); in the present species it will be found first to bend at right angles towards the nervure above it, and then to slope towards the margin, while the little cross nervure (discal transverse) which joins it to the next below, meets it very much nearer its upward bend than in *Musca domestica*. The front edge of the wing is bounded by the strongest of all the nervures, the costal, which is furnished, towards the base, with a row of short bristles. To the naked eye the wing appears to consist only of membrane and to have no clothing of any kind; but microscopic examination shows a multitude of extremely minute hairs distributed all over its surface, but very evenly and regularly disposed. There are also larger hairs on the nervures, which may perhaps be sensory in function.

The wings can be vibrated with marvellous rapidity, sufficiently so to produce a recognisable musical note. Attempts have been made to determine the number of vibrations per second by observing the pitch of the note. The usual pitch of a fly's hum is somewhere about the notes E or F, and the corresponding number of vibrations would be something between 320 and 350. The characteristic *buzzing* of our bluebottle, however, is not due to the vibration of the wings, nor, like the shrill song of the grasshopper, or the squeak of the water-beetle, to the friction of one part of the body against another; for Landois discovered that the thorax of a bluebottle continued to buzz with scarcely diminished vigour after the separation of the wings, legs, head, and abdomen. There is also a large and beautiful yellow-banded fly, called *Sericomyia borealis*, not uncommon in our mountainous districts, which has by several observers been noticed to "sing" whilst at *rest*. The Rev. J. Hellins, of Exeter, thus writes of it in Dec. 1881: "One day during the past autumn I went with a small party for a walk on Dartmoor, near Okehampton; after some miles of rough tramp up and down several tors, as the afternoon was drawing on, we found ourselves on a heap of stones on the top of Cawsand, and were glad to rest there awhile; before long, a piping sound was audible, and one of the party said the wind was whistling; but to this explanation I demurred, having some recollection of having heard the noise before; so, looking round, I soon saw several large flies resting on the stones, and was presently able to convince my friend that the sound came from them." In the case of the bluebottle, at least, and also probably in that of the other fly as well, the sound-

producing organ is connected with the thoracic spiracles, or breathing apertures, and the harsh and stridulating character of the sound suggests what appears to be really the case, that it is caused by the vibrations of hard solid bodies. A hemispherical cavity intervenes between the spiracle and the main tracheal trunk, and in this are situated some hard chitinous processes, by the vibrations of which it is believed that the sound is produced.

Closely connected with the remarkable power of the wings is the peculiar development of the thorax, which is so characteristic of the Diptera. Roughly we speak, with reference to insects in general, of the second apparent division of the body as the thorax; but it by no means follows that the part occupying that position and most distinctly visible when viewed from above, is homologically the same in all cases. The complete thorax is composed of three segments called respectively pro-, meso-, and meta-thorax; but in the more highly specialised groups of insects these three are not equally developed, and sometimes it is one, sometimes another of the three parts, the development of which on the upper surface preponderates over that of the rest. Thus in the Coleoptera (Beetles) and Hemiptera (Bugs), what is frequently called the thorax, on the dorsal view, is in reality only the prothorax; in the Hymenoptera (Bees, &c.) it consists mainly of both meso- and metathorax, and in the Diptera almost entirely of the mesothorax. This is the division to which the fore-wings of all insects are attached; and as in the Diptera this is the only pair of wings that is developed as such, the peculiar conformation of the thorax of a fly finds herein an explanation. The chief thoracic muscles are not attached to the wings themselves, but run from one part of the walls of the thorax across to the opposite wall, so that the greater part of the vibration of the wings is produced by alternating changes in the shape of the thorax.

At the base of each wing is a double membranous scale, the "*alula*" or "winglet" (Fig. 3); each of its divisions

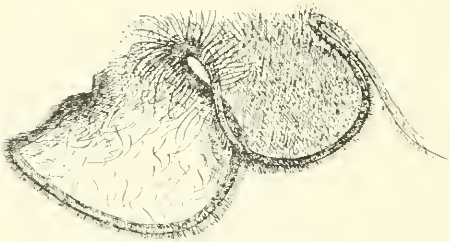


FIG. 3.—RIGHT WINGLET OF BLUEBOTTLE (*Calliphora*).

has a rounded and thickened outer edge, and the membrane is extremely closely covered with minute hairs similar to those on the wings, the larger part having in addition some long flexible hairs arranged pretty regularly but not closely in rows. The free edge of each is also very closely fringed with delicate hairs. When the wings are stretched out for flight, these scales form a continuation of their area as far as the centre of the hind margin of the thorax. Hence the inner scale has, as shown in the accompanying figure, a sloping edge where it fits under the side of the triangular termination of the thorax. But when the wings are closed, the outer scale is folded over the inner along their line of junction, as well as under the wing itself, so that they lie one upon another like the leaves of a book. It is impossible to say what is the significance of these *alulæ*: though connected with the wings, they can hardly have much influence upon flight, and the peculiar arrangement of the double fold, together with the remarkable profusion of hairs, seems to suggest some other function. They reach their highest development in the family *Muscidæ*.

A little distance beneath the larger fold of each *alula*, and entirely overarched and concealed by it, is an organ (Fig. 4) which is highly characteristic of flies; it consists of a slender stalk carrying a globular expansion at its outer end, and near the point of attachment of the stalk to the thorax are three minute sets of rows of papillæ with hairs. These stalked globes are called *halteres*, balancers, or poisers; they are most conspicuous in such flies as the daddy long-legs, or crane-flies, and in the bluebottle are reduced to extremely small dimensions, so that they are not likely to be noticed at all unless carefully looked for. It is curious that the development of the *alula* is always in inverse proportion to that of the *halteres*. Though so minute, their structure is sufficiently elaborate to suggest that they must be of considerable importance in the economy of the insect; and many different functions have been, more or less conjecturally, assigned to them. Their names, as above, indicate a notion once current that they helped the insect to maintain its equilibrium during flight; they have, again, been considered to be organs of hearing, or to be in some way connected with respiration. Situated as they are on the metathorax, they appear to be the representatives of hind wings.

FIG. 4.—BALANCER OF BLUEBOTTLE (*Calliphora*). SHOWING BASAL PAPILLÆ AND NERVE.

The legs of the bluebottle consist of the usual parts, and there is nothing of special interest or importance till we come to the feet. All the tarsi consist of five joints each, and are terminated by a pair of curved claws, under each of which is placed a fleshy pad fringed with hairs, and between the pads is a straight sharp-pointed spine. In these pads, or "pulvilli," as they are called, lies the secret of the power flies possess of running over surfaces in any position, often in defiance of gravity. A fly finds no more difficulty in running up or down a vertical window-pane, or across a ceiling, than in walking over a perfectly horizontal surface. This is not the case with all insects, many of which would struggle in vain to mount a perpendicular glass surface; hence it cannot depend entirely upon the claws, for these are developed in all insects, and would therefore give all equal facilities; no doubt the claws are of some help when the surface is at all irregular, as, for example, on a ceiling; but they can hardly be of much use in travelling over glass. We therefore look to the pulvilli for the explanation. It was at one time supposed that their efficiency depended upon atmospheric pressure, and that they acted like suckers, the edges being closely applied to the surface, and the centre part pulled up so as to create a vacuum beneath. This explanation, however, seems to be negatived partly by the absence of any mechanism to produce such a vacuum, and partly by the presence of great numbers of minute hairs on the under surface, which could hardly do otherwise than interfere with such a close application of the edges of the pad to the surface as is required by the hypothesis. The mechanism which brings about these curious results must rather be sought for in the hairs

themselves. The pads are, in fact, hollow and contain protruding into their cavity the nipple-shaped ends of a sac which occupies more or less of the interior of the last four tarsal joints. This sac secretes a perfectly clear, viscid liquid, which exudes into the pad, and from that into the hairs which project from it. These hairs, which are said to number about 1,200 on each pad, are hollow, terminate in tubular orifices, and are kept full of the secretion. Hence the entire surface of each pad is crowded with a number of viscid points; and as there are in all twelve pads, two to each foot, these, when applied to the surface over which the fly is walking produce an adhesion sufficiently strong to support the slight weight of the insect. The viscid liquid soon hardens on exposure to the air, but no doubt remains liquid while covered by the pad. Thus the insect is, as it were, at every step, temporarily glued to the surface over which it is travelling, and leaves on a clean surface little rows of dots as its footprints. This does not necessarily involve any violent strain in wrenching the foot off again, since the tarsus is raised obliquely and each row of hairs is therefore successively detached, somewhat in the same way as a piece of court plaster may be easily removed from the hand by taking it up at one end and raising it obliquely, though it might resist a considerably greater strain if merely pulled at one end without raising, all the points of contact then combining to resist the strain.

(To be continued.)

HINDU ARITHMETIC.

By Frederic Pincott, M.R.A.S.

EUROPEANS who have resided in India have frequently expressed astonishment at the rapidity with which arithmetical calculations are mentally made by very small Indian boys. Some account, therefore, of the Indian method of teaching arithmetic, which I believe to be superior to the English methods, will probably be interesting to the readers of Knowledge.

The arithmetical system of Europe was revolutionized by India, when the so-called Arabic figures which we daily use were borrowed by Arab traders to the Malabar coast, and by them introduced into Europe. It was Indian intelligence which devised the method of changing the values of the numeral symbols according to their positions. This ingenious conception rapidly superseded the older methods, and gave enormously increased facility to arithmetical computations as compared with the Greek and Roman and the older Arabic methods.

In order to explain the present Indian system of arithmetic, it is necessary to premise that the *Pandhes*, or schoolmasters, employ a number of terms unknown to English teachers. These terms have been invented for the purpose of facilitating calculation, and the astonishing results achieved cannot be understood without comprehending the terms employed. The strangeness of the names of the figures and fractions arrests the attention of every student of Hindi. Few Europeans attempt to master the fractions; and there are some who, after many years residence in India, cannot repeat even the numbers from one to a hundred.

Indians use monosyllables similar to ours, from 1 to 10; but from that point the words are built on the model of "1 and 10," "2 and 10," "3 and 10," &c., up to "8 and 10," but the word for 19 means "minus 20."* After 20 the same method is continued; "twenty-one" being impossible, the form is invariably "1 and 20," "2 and 20," up to "minus 30," "30," "1 and 30," and so on. This method of nomenclature goes back to remote antiquity; for the old Sanskrit language presents the same peculiarity.† The object of this nomenclature is to facilitate computation; for, in reckoning, the mind has to deal with the even tens, the simplest of all figures to multiply. Thus the question "Nine times nineteen?" is not a simple one to an English child; but the Indian boy would be asked "Nine minus-twenties?" In an instant he knows that he has only to deduct 9 minus quantities from 9 twenties, and the answer 171 comes before the English boy has fully realized the question. The formidable difficulty of the 9 is thus completely got rid of by a mere improvement in nomenclature.

Another advantage that the Indian boy has is the use of short, mostly monosyllabic, terms for every ascent in the decimal scale; thus such lumbering expressions as "one hundred thousand" are unknown to him, the simple word *lākh* conveying the idea fully to his mind. So also "one thousand millions" is *arb*; "one hundred thousand millions" is *kharb*, and so on. The advantages of this terseness must be at once apparent.

It is, however, with respect to fractional numbers that the advantage of the Indian system of nomenclature becomes most conspicuous, when once understood. They employ a large number of terms, which are given below.‡

These terms are *prefixed* when used in combination with whole numbers, the object being to present the special modification to the mind before the number itself is named. Complicated as this nomenclature appears at first sight, its difficulties disappear when brought to the test of practice. It is the outcome of centuries of practical experience; and the thoughtful application of means to an end. It will be sufficient to illustrate the use of these words, and the extraordinary arithmetical facilities they afford, if I explain the use of *paune*, that is $\frac{3}{4}$, that being the fraction which the English child has most trouble with. The Indian boy knows no such expression as "two and three-quarters," in fact the term "three-quarters" in combination with whole numbers, has no existence in his language. His teacher resorts to the same device as has been explained when speaking of the figure 9; he employs a term which implies "minus." By this process $2\frac{3}{4}$ becomes *paune tin*, that is "minus 3," or "a quarter less 3," and, in the same way, $3\frac{3}{4}$ is *paune chār*="minus 4," and so on.

Precisely the same plan is adopted with reference to the term *sawā*, which implies "one quarter more"; thus $3\frac{1}{4}$ is *sawā tin*="plus 3"; $4\frac{1}{4}$ is *sawā chār*="plus 4," &c. &c. It will now be seen that the *whole* numbers form centres of triplets, having a minus modification on one side, and a plus modification on the other. This peculiar nomenclature will be clearly apprehended by the following arrangement:

$2\frac{3}{4}$	paune-tin	-3	$3\frac{3}{4}$	paune-chār	-4	$4\frac{3}{4}$	paune-pānch	-5
3	tin	3	4	chār	4	5	pānch	5
$3\frac{1}{4}$	sawā-tin	$+3$	$4\frac{1}{4}$	sawā-chār	$+4$	$5\frac{1}{4}$	sawā-pānch	$+5$

In multiplying these fractions, therefore, the Indian

* This is also the original meaning of the English words *eleven*, *twelve*, &c., up to *nineteen*.

† In the ancient language there was also an optional form in conformity with the English method.

‡ Pā,o $=\frac{1}{4}$; ādh $=\frac{1}{2}$; paun $=\frac{3}{4}$; panne $=-\frac{1}{4}$ ($\frac{1}{4}$ less than any number to which it is prefixed); sawā $=1\frac{1}{4}$ ($\frac{1}{4}$ more than any number to which it is prefixed); sāṛhe $=+\frac{1}{2}$ ($\frac{1}{2}$ more than any number to which it is prefixed); deṛh$=1\frac{1}{2}$ (a number+half itself); pawannā $=1\frac{3}{4}$; aṛhā,i$=2\frac{1}{2}$ (twice and a half times any number); hūṅṭhā$=3\frac{1}{2}$; ḍhauṅchā$=4\frac{1}{2}$; pahūṅchā$=5\frac{1}{2}$.

boy has to deal with only the minus and plus quantities. A simple instance will illustrate this. "Seven times ninety-nine and three-quarters?" would be a puzzle to an English child, both on account of its lumbering phraseology, and the defective arithmetical process he is taught to employ. The Indian boy would be asked, "*sāt paune-sau?*" three words meaning "seven minus-hundreds?" The very form of the question tells him that he has only to deduct seven quarters from 700, and he instantly answers $698\frac{1}{4}$. Equal facility is found with any similar question, such as "five times fourteen and three-quarters." The Indian boy is asked, "pânch paune-pandrah?" *i.e.* "five – 15's?" As the words are uttered he knows that he has only to deduct 5 quarters from 5 fifteens, and he answers at once "paune chau-hattrah," *i.e.* "a quarter less four-and-seventy" ($73\frac{3}{4}$).

So much for the machinery with which the Indian boy works. The more it is understood, the more it will be appreciated. It is, undoubtedly, strange to English preconceptions; but it would be a real blessing to our country if corresponding suitable terms were invented, and this admirable system were introduced into all our schools.

Some Europeans have sought to account for the surprising results attained by Indian children, by attributing them to special mental development due to ages of oral construction. It is perfectly true that Indians rely more on their memories than on artificial reminders, and no one can come into contact with the people without being struck by their capacity for remembering. It is well known that many of the ablest men the country has produced could neither read nor write; but they hardly missed those accomplishments, for their minds were frequently stored with more information, which was more ready to their command, than that possessed by the majority of book-students. It is well known that Ranjît Singh could neither read nor write, but he knew all that was going on in every part of a kingdom as large as France. He was an able financier, and knew at all times accurately the contents of all his treasuries, the capacities of his large and varied provinces, the natures of all tenures, the relative power of his neighbours, the strength and weakness of the English, and was, in all respects, a first-class administrator. We commit the mistake of thinking that the means to knowledge is knowledge itself. This induces us to give all the honour and prizes to reading and writing, and leads us to despise people—whatever their real attainments may be—who have not acquired the knack of putting their information on paper. It ought to modify our opinion on this point to reflect that the architectural triumphs of India were nearly all built by men who could neither read nor write. Another illustration of dependence upon memory instead of paper can be found in the Indian druggist, who will have hundreds of jars, one above another, from floor to ceiling, not one of them marked by label or ticket, yet he never hesitates in placing his hand on the right vessel whenever a drug is required. The same, to us, phenomenal power of memory is shown by the ordinary washermen, who go round to houses with their donkeys, and collect the clothes, some from one house, some from another. These they convey to the river and wash, and in returning with the huge pile, never fail to deliver each particular article to its rightful owner.

The Indian boy's first task is necessarily to commit to memory the names of the figures from 1 to 100. He is next taught that there are nineteen places for figures, and their names. These correspond to our units, tens, hundreds, &c.; but the monosyllabic curtness in the names of the higher numbers is his distinct advantage.

What we call the multiplication table then begins. In England the multiplier remains constant, and the multiplicand changes; thus, children repeat "twice one two; twice two four; twice three six," &c. &c. In India the boy is taught to say "one two, two; two twos, four; three twos, six," &c., his multiplier changing, while the multiplicand remains fixed. Another peculiarity is this, he begins at 1, not at 2; and this furnishes him with a series of most useful collective numbers. Here, again, the English language lacks terms to translate the first table, but an idea may be gained from the following attempt:—

One unity ...	...	...	one
One couplet ...	...	...	two
One triplet ...	...	...	three
One quadrat...	...	...	four
One pentad ...	...	...	five
&c.			&c.

These names for aggregates, as distinguished from mere numerals, are of much value to the boy in the subsequent processes, and give him another distinct advantage over the English lad.

In learning these tables the boy is not carried beyond 10, that is, he goes no further than "two tens, twenty," "three tens, thirty," &c.; but to make up for that forbearance he is carried on in this process of multiplying figure by figure not only to 12, or (as is sometimes done in England) up to 20, but he goes on through the thirties, and does not make his first halt until he gets to "ten forties, four-hundred." In achieving this result something more than mere memory is brought into play, for he is taught to assist his memory by reference from one table to another, thus the first half of the six table is contained in the three table, &c.

A short supplementary table is next taught beginning at 11×11 to 20×11 and then proceeding to 11×12 to 20×12, and so on up to 20×20. This method reduces considerably the tax on the memory; for one half of the table is obviously the same as the other half, and therefore only half calls for special effort.

The boy has now committed to memory the multiplication of every figure from 1×1 to 20×20, and in addition he knows the multiplication of every figure up to 40 by the ten "digits." It will be observed that both tables end at 400 (10×40 and 20×20); in fact, 4 is the most important factor in Hindu arithmetic, all figures and fractions being built upon multiples and fractions of it.

At this point, instead of practising on imaginary sums in the hope of learning arithmetic empirically, the Indian lad immediately proceeds to tables of fractions, the first being the multiplication of every figure from 1 to 100 by $\frac{3}{4}$. Here, again, according to English ideas, $\frac{3}{4}$ would be the last fraction we should attempt; but in India it is the first, and, by the superior system of nomenclature there in use, it is a very easy affair. The boy, knowing the multiplication of the whole numbers, is taught to deduct the half of the half ($\frac{1}{4}$), and the thing is done. Memory is assisted by observing that every multiple of 4 is a whole number, and that the number below it will always be a *sawā* of the next lower figure, and the number above it always a *paune* of the next higher figure. Thus in answer to the question $\frac{3}{4} \times 36$ the Indian boy says mentally, 18, 9, 27; he also knows that 36 is the 9th multiple of 4, and by immediately deducting 9 can get his 27 that way also. Knowing, also, that 36 is a multiple of a 4 yielding 27, he knows that 35 will yield *sawâ chhabbîs* ($26\frac{1}{4}$); and that 37 will yield *paune aṭhâ,îs* ($-28=27\frac{3}{4}$). In this way three-fourths of the table is a matter of logical necessity, resting on the elementary table previously acquired.

In the next table the boy is taught to multiply every

figure from 1 to 100 by $1\frac{1}{4}$. This, of course, is precisely the reverse of the last; the $\frac{1}{4}$ is ascertained and added, instead of being deducted. Here again the multiples of 4 are whole numbers; but the figures preceding result this time in a *paune*, and those next following in a *sawâ*. This table also costs but little effort when thus taught.

The next table teaches the boy to multiply from 1 to 100 by $1\frac{1}{2}$, and, of course, means simply adding half the multiplier to the figure itself.

The next step, multiplying from 1 to 100 by $1\frac{3}{4}$, is achieved by simply adding three-quarters of the multiplier to the multiplier itself. The "three-quarters" table has been already acquired by the boy, and he has therefore only to add any given multiplier to it. Thus, if asked, "What is 27 times $1\frac{3}{4}$?" he knows that 27 *paunes* are $20\frac{1}{4}$; he has, therefore, only to add this to the 27 itself, to get $47\frac{1}{4}$ as the instant answer.

The boy is next exercised in multiplying 1 to 100 by $2\frac{1}{2}$, and he is taught to do this by adding half the multiplier to the "twice-times" table.

Then follow similar tables multiplying by $3\frac{1}{2}$, $4\frac{1}{2}$, and $5\frac{1}{2}$, and the results are arrived at instantaneously by adding to the "three-times," "four-times," and "five-times" tables half the multiplier in every case.

In all these tables the rapidity and simplicity is in great part due to the terms employed. The boy is not asked to "multiply seventeen by three-and-a-half," or "What is three-and-a-half times seventeen?" or puzzled by any other form of clumsy verbosity. The terms he uses allow him to be asked "*sattrah hûnthe?*" (seventeen three-and-a-halfs). His elementary table has taught him that $17 \times 3 = 51$, and he knows that he has only to add half 17 to that, and the sum is done.

The final task of the Indian boy is a money table, which deals with a coinage which may be thus summarised:—

16 damri = 1 takâ.
16 take = 1 ânâ.
16 âne = 1 rûpi.

There is a small coin called *dâm*, three of which make 1 *damri*; and, therefore, 48 make 1 *takâ*, and 96 = *ânâ*, 4^2 being still the unit. The table imparts a familiarity in combining these coins together.

This completes an Indian boy's most elementary course of arithmetic, and a little reflection on the great facility for computation which Indian children show, and the simplicity of the means by which it is effected, ought to make us rather ashamed than boastful of our own defective methods. The insolence of ignorance has induced us to despise the Indian method, and to endeavour to introduce into India our own miserable muddle. The proportion of our success in this attempt will be the measure of India's misfortune. It would be far wiser to endeavour to understand a subject before we condemn it, and, in the present instance, it would be well if suitable terms could be adopted which would allow the admirable system of Indian *Pâudhes* to be introduced into English schools.

WALKS IN THE SYDNEY BOTANIC GARDENS.

By C. Parkinson, F.G.S.

(Continued from page 74.)

AMONG the numberless species of fig in the Sydney gardens there is none more attractive than the sacred fig (*F. religiosa*), a specimen of which Tennent describes at Kandy as the most ancient existing tree in all the world. It is instructive to note how exotic plants—known to us in England under glass, and in dwarfed condition only—here fall naturally into their respective orders. An example of this I saw in the india-rubber plant (*Ficus elastica*), growing as a tree in the sub-tropical gardens; at home few recognise in the broad leaves a species of fig. This occurs in a hundred cases.

Without actual experience it is hard to form any conception of the intense brilliancy of the foliage plants, whole beds of which enliven the terraces. The variegated croton has mottled leaves of all tints. Mr. Moore, the Curator, led me to one bed—his special pride—a very blaze of delicate crimson, from seedlings of the amaranthus tricolor, a miniature forest resplendent in the clear atmosphere and bright light of the South Pacific. The fresh tender shoots looked on fire in the dazzling mid-day sun, and in the evening all the leaves became comparatively dull. Close to these beds there was a trellis-covered way—a bower of creeping plants, roses, passion fruit, with red, yellow and blue trumpet-flowers (*Bignonia*)—leading to the aviary. Among the caged birds I found the stupid-looking wood-hen from Lord Howe's Island, evidently akin to the wingless apterix of New Zealand. The Australian native companion was there, with long legs, bluish feathers, and crane-shaped bill. It has enormous power in the lower extremities, stamping on rats and such vermin food with blind passion. Near to the aviary two gorgeous trees covered with rich blossom excite the admiration of all comers. One is the jacaranda, of Brazil, and the other a member of the loosetrife family, from Java, the *Lagerstræmia indica*, with heavy masses of purple-rose flowers.

At the point where the old and more recent gardens join, a pair of Norfolk Island pines (*Araucaria excelsa*) tower upwards, straight as a dart, a hundred feet or more. Between forty and fifty years old, they represent the earliest trees planted *in situ*, and are noble specimens of the fine conifer. The peculiar beauty of this araucaria is, I think, derived from the branching pinnæ pointing upwards; but *A. Cookii*, if well developed, has a more perfect shape, and the "monkey-puzzle" like *Araucaria Bidwillii*, the bunya-bunya pine of Queensland, is a shapely tree. The latter for some reason grows far better in Melbourne than in Sydney, while the converse is the case with regard to the Norfolk Island pine.

I spent a pleasant morning with the director examining the different spices, &c., gently browsing—so to speak—on strongly flavoured leaves, with a view to detecting their identity. The cinnamon bark no one could mistake, but other kinds are not so readily distinguished. In my ignorance I had thought allspice was a blended product of the cook's spice-box. I was, therefore, surprised to find the specific tree, and fairly puzzled with the mixture of flavours which obviously gives the name to the plant. Hard by the camphor laurel grew, strong with essential oil. Tea plants from India and China stood side by side, and coffee, in both flower and fruit, from Ceylon. Although the berry is produced in Australia, the active properties are lost, and the plant is valueless except as a botanical specimen. The crimson, yellow, and orange canna, of the arrow-root tribe, remains in full flower for many months of the year, and is consequently much used throughout the garden, and the various coloured bouvardia of Japan, appears equally hardy and prolific—a plant of which stove-house specimens give a very humble idea.

At a sudden turn I came upon a most charming nook. In the foreground there was a still pool, in which the graceful Egyptian papyrus flourished. A monument to Allan Cunningham, explorer and botanist, stood half hidden in a tropical forest glade behind, where feathery palms, tree ferns, and the like, grew in delightful confu-

sion. It is strange how different trees influence each other in degree of growth when massed together. A slow-growing palm had been developed in half the usual time by the attraction of loftier palms and tree ferns.

Many interesting cycadaceous plants were grouped in a separate bed. Of this order the macrozamia, of New South Wales, supplies an undoubted link, although degenerate with the palæontological remains from the Purbeck beds. The leaves grow almost from the ground without a trunk, like so many fronds, and are simply pinnate; but I saw a rare species with bifurcating pinnæ. The large date palm (*Phœnix*) was in fruit, with the cocoa-nut (*Cocos flexuosa*), and a magnificent specimen of *Jubæa spectabilis* from Chili. The dwarf fan palm (*Chamærops humilis*) looked very insignificant by the side of so many giants from Brazil, China, Jamaica, the East Indies, Mauritius, New Caledonia, and East Asia. A Queensland palm, *Calamus Australis*, is called the "lawyer tree," because the long, thorny appendages lurking in the bush tear the traveller's flesh; and if once they hook on, are difficult to detach. The distribution of palms in Australasia is irregular. In North Queensland, of course, the greater number are found, being nearer to the tropics. Cabbage-tree creek, in Victoria, is the only habitat for palms in that colony, and it is curious to find this isolated patch severed from all relations. New South Wales, with 800 miles of coastline, has but four species. New Zealand has, I believe, but two palms, including the Areca, notwithstanding the hot climate of the north island. Lord Howe's Island, oddly enough, has four indigenous and peculiar species, and Norfolk Island boasts of two. In New Guinea, I suspect, palms and many plants remain to be discovered. The palmæ of the world appear to thrive in the Sydney gardens, but I saw none more beautiful for horticultural purposes than the glaucous-leaved variety of the Phœnix, one of the treasures of the collection. Then I passed on to the screw-pine (*Pandanus*), with groves of banana, plantain, gaudy-flowered strelitzia, and the far-famed traveller's tree, which, to the unaccustomed eye, is singularly like a banana; it has a refreshing fluid contained in the stem. Typical bromeliaceæ form an undergrowth of ugly crowns; the opuntia, with great yellow flowers, runs riot where it will.

To those who know only the British herbaceous weeds of the Spurge tribe, the size and great variation in the *Euphorbiaceæ* is wonderful. The croton and poinsettia, already mentioned, belong to the order. The cactus-like *Euphorbia grandicornis* is widely different from the handsome drooping tree, *Excæcaria parvifolia* (gutta-percha). Nearly all have poisonous juices, and the South Sea islanders steep their spears and arrows in some fatal plant of the order; even the tapioca species is deadly until the virulent juices have been extracted. It is dangerous to touch unknown plants in a tropical garden. The great nettle tree (*Laportea gigas*) produces violent irritation, exceedingly painful for many hours. I have heard that the bark of the same tree affords an antidote, but had no inclination to test the truth of the assertion. The false pepper tree (*Schinus molle*), with finely-cut foliage and coral berries, has an exceedingly pungent taste, quickly bringing tears to the eyes. I saw a species of rhus which it is dangerous for many persons to approach. Mr. Moore himself had a narrow escape, some years ago, with this plant. After an examination of the leaves, he inadvertently rubbed his eyes. Next day his features were almost obliterated by intense swelling, which gradually passed down the body to the extremities; life, for a long time, was in jeopardy, and a photograph, taken by an officer of the ship when the malady was at its worst, shows the swollen face with simply a large slit for a mouth; no eyes or nose to be seen. The case was reported in the *Lancet* at the time, and the dangerous properties of the plant are now fully recognised. Even contact is not always necessary to produce the unpleasant symptoms, as many have found to their cost.

That solid grass (*Saccharum officinarum*), more commonly known as the sugar cane, finds a place in the gardens, together with a plant much cultivated in Australia for its sweet properties, *Sorghum saccharatum*, which, with improved crushing machinery may yet be extensively used in the sugar industry. At present I think cattle are fed on what is grown.

The Acacia order is largely represented by the native wattles, and going farther afield, by the minute-leaved Peruvian inga, with feathery crimson flowers—a kindred species has tufts of white flowers like bog-cotton, which expand only at night. English oaks are scattered here and there, but nearly all grow pipe-stemmed. Possibly until they learn to shed the leaves and bark at the right season, and adapt the foliage to the changed influences of light, the timber will never grow round. After the Norfolk Island pine the most perfect tree in the garden is the *Grevillea robusta*, a proteaceous species, with leaves which reminded me of a gardener's hybrid in the south-west of England the oak-leaved beech. The next is a coniferous plant from Mexico, known as "Montezuma's tree," from the fact that under one of them that unfortunate potentate signed his abdication. It has close, finely-cut pinnæ, almost like the inga leaves.

There are no mangrove swamps near the Botanic Gardens, but a few miles up the Parramatta they can be seen, islets in mid-stream, flooded and inaccessible. The beautiful white-faced heron, a medium-sized bird with blue feathers and red legs, breeds here in perfect safety, for approach is difficult.

The climbing rata of New Zealand, one of the most brilliant flowers of those islands, grows in an uncertain manner at Sydney. The slender stem is rooted to the ground, but frequently the seeds lurk in crevices of the supporting tree, developing a fresh plant, and finally choking the accommodating host; it is *not*, however, a parasite.

The epiphyte ferns, as opposed to true parasites, are worthy of notice, both for curious structure and gigantic size; they hang to the trunks of trees like green-brown baskets. Two kinds are natives of Australia: the stag-horn (*Platycerium grande*) I have seen, *weighing a ton*; the elkhorn (*P. alicorne*) is much smaller in bulk.

In another direction, fresh collections of ornamental shrubs border the paths: a justicia with handsome labiate-looking clusters of mottled flowers; scarlet coral trees (*Erythrinæ*); gardenia; and the fragrant tabernæmontana of Ceylon, having irregular corollas with waxy white flowers. There were also the native Christmas tree, and flaming sterculia, from Queensland. An order we in England know little about, except from the evergreen ivy, is largely distributed in the islands of the Southern Ocean—the Araliaceæ. It includes widely different genera such as the panax, having prolonged, coriaceous leaves, like the defensive weapon of a sword-fish, and the aralia with deeply cut, digitate foliage, similar to a horse-chestnut. It is a great advantage to find beneath each plant a label clearly inscribed with scientific name, authority, order, habitat, and local name; all of which, if Botanic Gardens are to be of educational value, are absolutely necessary. A space is set apart for a typical collection of plants, illustrative of Exogenous and Endo-

genous classes, and some effort has been made to group plants of medicinal value; while fibres and economic vegetable products are in the museum.

FLYING DRAGONS.

By R. Lydekker, B.A.Cantab.

Legends of Flying Dragons were rife both among the ancients and also during the middle ages, but it was reserved for the great founder of the science of comparative anatomy—the illustrious Cuvier—to show that such creatures had really once existed, and were not merely the dreams of the poet and the herald. Thus in the year 1784 one Collini described the skeleton of an animal found in the fine-grained limestones of Bavaria, so extensively quarried for the use of the lithographer, which he regarded as indicating an unknown marine animal. When, however, this curious specimen came into the hands of Cuvier, about the year 1809, he at once recognised it as the remains of a reptile endowed with the power of flight, for which he proposed the name of Pterodactyle; the name being compounded from the Greek words for a wing and a finger. In thus proving, once for all, the former existence of veritable Flying Dragons it must not, however, be supposed that Cuvier thereby authenticated the old legends which represented these creatures as capturing human beings, and being themselves in turn destroyed by valiant champions. These real Flying Dragons, on the contrary, existed long ages before man or any of the higher types of mammals had made their appearance on the globe; being, indeed, characteristic of the so-called Secondary epoch of the geologists, the relations of which to the present epoch we have endeavoured to indicate in the article on Fish Lizards which appeared in Knowledge for November last.

Before the master mind of Cuvier indicated the true affinities of the original specimen of the Pterodactyle, one naturalist had regarded it as a bird, and another as a bat, and it will therefore be interesting to glance at the chief features in the bony anatomy of these creatures, to see how the great anatomist was justified in his conclusions. For this purpose we give a figure in the accompanying woodcut of the skeleton of a small Pterodactyle obtained from the Lithographic limestones of Bavaria, and remarkable for its beautiful state of preservation. It will be seen from this figure that the neck of these creatures is comparatively short, and has but few joints, or vertebræ, in which respect it is unlike that of a bird. The skull is, however, wonderfully bird-like in the figured specimen, although in some species it is much shorter and more lizard-like. There are, however, certain features in the structure of the skull, into the consideration of which it would be difficult to enter in the present article, by which it is at once distinguished from the skull of a bird. The presence of a number of sharply pointed teeth (shown in Fig. 2) was, indeed, at one period regarded as another point in which Pterodactyles differed from birds; but it has been subsequently found that many if not all the birds of the Secondary epoch were provided with teeth, while in some Pterodactyles those organs were wanting, as shown in Fig. 3. The most ready means of distinguishing a Pterodactyle from a bird is, however, to be found in the structure of the fore-limb. Thus it will be seen from Fig. 1 that the "hand" of a Pterodactyle carries three fingers furnished with claws, and a fourth extremely elongated finger which has no terminal claw, and supports the membranous wings. It is, on the whole probable that this elongated finger corresponds to the little finger of the human hand, the thumb being probably represented by the small splint-like bone seen at the wrist in Fig. 1; and in any case the finger in question is the outermost one, whether it correspond to the ring-finger or the little finger of the human hand. Now in the wing of a bird, on the contrary, neither of the bones corresponding to the fingers are greatly elongated, while the longest of these modified fingers is the one representing the index or fore-finger of the human hand, and is, therefore, the very opposite of the elongated finger of the Flying Dragons. This essential difference between the structure of the wing of a Pterodactyle and that of a bird is of such radical importance as

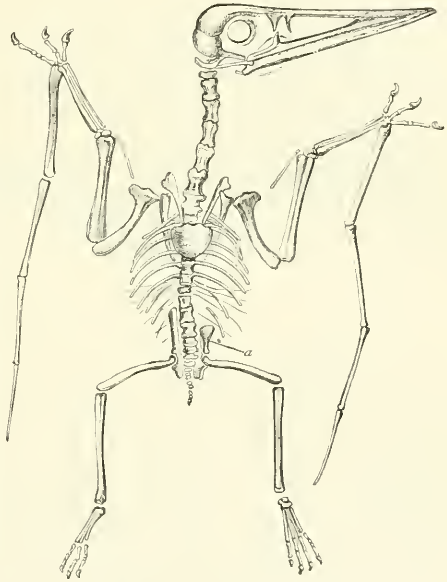


Fig. 1.—The Skeleton of a Small Pterodactyle, from the Lithographic Limestones of Bavaria. The creature is lying on its back, with the head bent to the left side. *a* indicates the left pubic bone; the haunch bone, or ilium, being shown on the opposite side. (After Von Meyer.)

to indicate that the Flying Dragons could not possibly have been the ancestors of birds; which (always assuming that we are right in regarding evolution as the true explanation of the mutual relation of the different groups of animals) were more probably descended from those extraordinary extinct reptiles commonly known as Dinosaurs.

The shield-like bone seen in Fig. 1, lying in the middle of the chest in front of the back-bone, corresponds to the breast-bone of a bird, and, like that of the majority of birds, has a keel projecting in front for the support of the strong muscles of the breast necessary to move the wing in flight. This remarkable similarity between the breast-bone of a Pterodactyle and that of a bird is a good instance of what comparative anatomists term an adaptive resemblance; that is, a resemblance caused by the circumstance that a particular organ or bone has to subserve the same purpose in two particular instances. It will further be observed from the figure that the skeleton of the Pterodactyle differs from that of an ordinary bird by the absence of the so-called "merry-thought" or furculum. Since,

however, that bone is either rudimentary or absent in the flightless birds allied to the ostrich, it cannot be regarded as a feature of first rank in distinguishing Pterodactyles from birds.

Having thus shown that our Flying Dragons cannot be classed with birds, it remains to mention why they should be placed with reptiles rather than with mammals. This point is, however, at once decided by the circumstance that the skull is jointed to the back bone by a single knob-like articulation, or condyle, instead of by the two condyles found in all mammals. If further proof were wanting, it is found in the circumstance that each half of the lower jaw consists of several totally distinct bones, as in all birds and reptiles; whereas in mammals it is composed of but a single piece.

With this glance at the general features of the skeleton of the Flying Dragons, we may proceed to notice some of the peculiarities of the different kinds of these creatures, and also what is known as to the structure of their wings. The true Pterodactyles, as is shown in Fig. 1, are readily

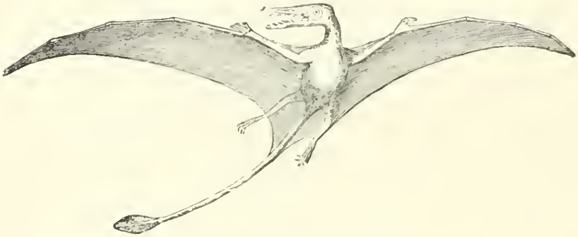


Fig. 2.—Restoration of a Long-tailed Flying Dragon, or Rhamphorhynch. One-seventh natural size. (After Marsh.)

characterised by the extreme shortness of the tail; but in another group, also found in the Lithographic limestones, the tail is as long as that of a lizard. The members of this second group are known as Rhamphorhynchs, and the restoration shown in Fig. 2 is taken from a beautiful example found some few years ago, in which the impression of the delicate membrane of the wing is preserved with as much sharpness as if made but yesterday. This and other specimens show that while the front edge of the wing was supported by the elongated finger, the wing extended backwards to embrace the greater part of the hind limb, while the extremity of the tail was furnished with a racquet-shaped expansion of membrane which probably served the purpose of a rudder during flight. Curiously enough, a slab of Lithographic limestone preserved in the museum at Haarlem exhibits a sinuous trail which is believed to have been caused by the extremity of the tail of one of these creatures as it walked across the soft mud now consolidated into stone. The impression of the wings shows that these consisted of a soft leathery membrane, probably something like that of the wing of a bat; and it is quite evident that there were no feathers either on the body or on the wings. The body, like the wings, was, indeed, in all probability entirely naked; and this circumstance militates against the suggestion that the Flying Dragons were warm-blooded creatures, since a protection of either fur or feathers is found necessary in the case of birds and bats to maintain their high temperature. The Rhamphorhynchs occur not only in the Lithographic limestone, which is situated near the top of the great Oolitic system—the system underlying that of the Chalk—but are also found in the much older Lias. Another group, also found in the Lias, are characterised by their short skull and the superiority in size of the front over the hinder teeth, in consequence of which they are known as Dimorphodonts.

Perhaps, however, the most remarkable forms found in the whole group are the toothless types, or Pteranodonts, of which a skull is shown in Fig. 3. In these creatures teeth were totally wanting, and the jaws were probably sheathed in horn, like those of the tortoises (see Knowledge for January), while the hinder or occipital region of the skull was produced into an enormous flattened spine, which also recalls a feature found in the tortoises. Whereas most of the forms we have hitherto noticed did not exceed a rook in size, some of the Pteranodonts were of enormous dimensions, one of them having a skull measuring upwards of four feet in length, and its expanse of wing being probably about twenty-five feet. These Pteranodonts are found in the chalk of the United States; but species nearly as large occur in the chalk of this country, although they were furnished with a powerful armature of teeth, and have been described under the uncouth and exceedingly misleading name of Ornithochirans the hand or wing of all the Flying Dragons being, as we have already said, as much unlike that of a bird as it well can be. These huge monsters flying through the air must have been a marvellous sight, and they afford one more instance that the wildest dreams of romance have not produced creatures one wit more wonderful than those which at one time had a corporeal existence upon the earth.

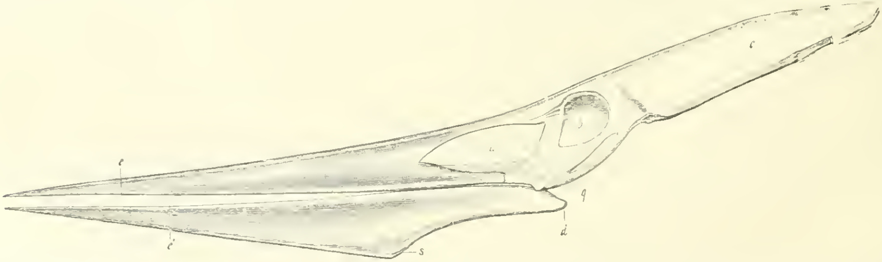


Fig. 3.—Left Side of the Skull of a Toothless Flying Dragon, or Pteranodont. One-sixth natural size. *a.* Vacuity in front of the eye; *b.* Socket of the eye; *c.* Occipital spine; *d.* Angle of lower jaw; *e.* Extremity of upper, and *é.* of lower jaw; *q.* Articulation of the skull proper with the lower jaw; *s.* Points where the two branches of the lower jaw diverge. (After Marsh.)

A Cluster of Deudrocalamus Giganteus (one of the Gigantic Berry-bearing Bamboos) growing in the Botanical Gardens, Ceylon

That the Flying Dragons were capable of sustained flight, like birds and bats, seems to be beyond reasonable doubt. It is further quite evident that the toothed forms were of carnivorous habits, and it was suggested years ago, by the late Dean Buckland, that while the smaller species may have subsisted on the dragon-flies and other insects that are known to have lived at the period when the Lithographic limestone was laid down, the larger ones may have preyed on fishes, and perhaps also on the small contemporaneous mammals. It is difficult to suggest what kinds of animals formed the food of the large toothed forms from the English chalk; but in the case of the toothless American monsters it may be pretty safely said that, if they preyed on fish, they must have had a capacious mouth and gullet, and swallowed their prey whole, after the fashion of pelicans and other fish-eating birds.

THE BAMBOO AND ITS KINDRED.

By R. Camper Day, B.A.Oxon.

If the many families of flowering plants were arranged either in the order of their utility to man or in the order of their abundance, the first place in the list would unquestionably be assigned to the great family of the Grasses. Of their omnipresence and abundance some idea may be obtained from the fact that at least four thousand different kinds have been described, and a German naturalist has estimated that they constitute a twenty-second part of all known plants. Their utility as food-producers becomes obvious as soon as we recall the names of Rice, Wheat, Barley, Oats, Rye, and Indian Corn, and remember how large a proportion of our food is made from their seeds. Most of these civilised and somewhat unnatural grasses have been so long under cultivation, and so much altered by man's selection, that they are totally unfitted to shift for themselves, and would soon become extinct if brought into competition with wild plants. The fact that the wild forms from which they are descended cannot now be identified with certainty shows that their cultivation must date from the very earliest ages. Rice alone is said to furnish more sustenance to the human race than any other single species; the common meadow-grasses, such as the purple-tipped *Anthoxanthum*, which fills the fields with its penetrating fragrance when the hay is newly mown, are almost the only food of sheep and cattle; and those tall and sturdy canes whose juice we squeeze out between rollers, and clarify and crystallise into sugar, are only modified stems of grass.

The largest of the family, and perhaps the most beautiful, is the tropical arborescent grass which bears the name of Bamboo. Although it is not cultivated for the sake of its seed, it has many admirable qualities, and wherever it grows in abundance it is applied to a variety of uses. "The strength, lightness, smoothness, straightness, roundness, and hollowness of the bamboos," says Mr. A. R. Wallace in his *Malay Archipelago*, "the facility and regularity with which they can be split, their many different sizes, the varying length of their joints, the ease with which they can be cut and with which holes can be made through them, their hardness outside, their freedom from any pronounced taste or smell, their great abundance, and the rapidity of their growth and increase, are all qualities which render them useful for a hundred different purposes, to serve which other materials would require much more labour and preparation. The bamboo is one of the most wonderful and beautiful productions of the tropics, and one of nature's most valuable gifts to uncivilised man."

In order that the accuracy of this eulogy may be appreciated, let us imagine the case of a shipwrecked man landing without any tools, except an axe and a knife, upon an island in which we will suppose that bamboos are the only vegetation, and let us see how far he could supply his needs with their assistance. One of his first requirements would be a house, and this could be provided with very little labour. The stems of one of the larger species, such as *Bambusa Brandisii*, driven into the ground, would form excellent uprights for the framework, which could be completed with lighter cross-pieces nailed to the uprights with pegs of the same material. A good roof could be made by taking broad strips split from large bamboos, and fastening them side by side with their concave surfaces uppermost, the interstices between them being covered with other pieces having their convex sides uppermost. Similar but flatter pieces laid upon the joists, and tied down firmly with strips shredded from the outer rind, would form a smooth and elastic floor such as could not be made out of other materials without a great expenditure of labour. Thin strips plaited together, or broad strips pegged side by side, might be used for the walls.

The furnishing of the house would be an easy matter, for bedsteads, chairs, brooms, baskets, cords, fans, bottles, mats, and hoes can be made of bamboo with the greatest facility. The water-tight joints of the stems form admirable water-vessels, and it would be easy to bring the water to the very door by a gently-sloping aqueduct of pieces of bamboo split down the middle and supported at intervals on cross-pieces arranged like the letter X. The jars made from the joints could be utilized not only for holding water, but even for boiling it. Mr. Wallace tells us that rice, fish, and vegetables can be boiled in them to perfection. The young shoots of the bamboo as they first spring from the ground are said to be a delicious vegetable, "quite equal to artichokes." That fish may be readily caught by the agency of the bamboo is shown by the many specimens of ingenious fish-traps exhibited in the museum at Kew. If we suppose our adventurer to take a thin stem of bamboo, and cut off the end obliquely just above a joint so as to leave a sharp edge, he would be provided with a hard-pointed and very efficient spear. In the same way he could supply himself with daggers and arrows; while from the more elastic species he could make himself a bow, using a thin strip of the outer rind for the bow-string. The lowest internode of *Arthrosylidium Schomburgkii*, which sometimes attains the extraordinary length of sixteen feet, far surpassing the length of the joints in all other bamboos (says General Munro), furnishes the "sarbican" or blow-pipe through which poisoned arrows are blown by the natives of Guiana. In the island of Celebes the only article of dress worn by the natives is a body-cloth called Kian Pakkian, made of bamboo slit into fine shreds, which are passed between the teeth and bitten until they are soft, when they are woven.

If after providing himself with these and similar necessaries our shipwrecked man found leisure to amuse himself, he might make Æolian flutes, such as Sir Emerson Tennant saw in Malacca, by boring holes in the stems of living bamboos, or he might construct a harp like that in the Kew Museum which was brought from Timor by Mr. Wallace. This harp is made from a cylinder of bamboo having a node at each end. Under a strip of the outer rind a quarter of an inch wide, a sharp knife is passed so that the strip is detached from the cylinder except at its two ends. The strip forms one of the harp strings. Two small wedges are pushed under it, and the portion between the wedges can then be sounded like the string of a guitar. It is also possible, and not very difficult, to make such

diverse articles as paper, pens, waterproof clothing, hats, wax, pickles, bird-whistles, rafts, pillows, fermented drink, and bridges from the same versatile vegetable. In the Kew Museum, which should be visited by everyone who wishes to see the varied uses to which bamboos can be applied, perhaps the most curious article is a headsman's knife lately brought by Mr. Franks from the south-eastern peninsula of New Guinea. This singular implement, which is shaped like a cheese-scoop and seems very ill-adapted to its purpose, is marked with numerous notches, each notch representing one of its victims; and it is accompanied by an artistic apparatus, also of bamboo, intended apparently to enable the executioner to carry the severed head.

The bamboo usually grows in a cluster of from ten to a hundred stalks, all springing from the same rhizome or root-stock. The rhizome is not the root but an underground portion of the stem. It consists of a number of segments about the size and shape of a banana and somewhat bloated in the middle. The banana-like segments are joined together irregularly by their tips, so that the whole rhizome forms a strong underground trelliswork admirably adapted to support the light and yet rigid stems that rise up from it. From the under side of the rhizome spring downwards the true root-fibres, numerous as the bristles of a broom.

The stem itself, as everyone knows, is smooth, polished, and cylindrical, and is divided into air-tight compartments by knots or nodes, which are the points at which the fibres of the stem cross over from one side to the other. The lowest ten nodes or so are usually bare, but from the upper nodes issue branches, as shown in Fig. 1. These are very slender as compared with the main stem, and carry the foliage leaves, one of which is shown in Fig. 2. In most species the leaves are rather small, but in some they are very large. The species named *Planotia nobilis* by General Munro, a native of New Granada, has the largest leaves of any kind of grass; they are often a foot in diameter and fifteen feet in length. It will be seen that the leaf given in the figure (*Bambusa vulgaris*) is not quite symmetrical in shape. It is smooth on both sides, except that along the edges there is a roughness, plainly perceptible to the finger, such as is often found in grass-leaves. Each leaf bends gracefully downwards, and the whole plant has a very light and feathery appearance as it waves in the wind. Our full-page illustration is a photograph of a cluster of *Dendrocalamus Giganteus* (one of the berry-bearing kinds) growing in the Botanical Gardens, Ceylon.

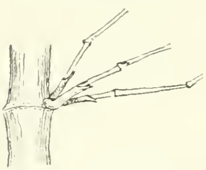


Fig. 1.—Branches from Node of Bamboo.

The most important part of the bamboo, from a botanical point of view, is the flower, which roughly resembles the flower of our common grasses. The flower of grass is enclosed in hard scaly leaflets called glumes; it usually has three stamens and one seed-vessel. There may be only one flower enclosed in the glumes (as in Foxtail grass), or more (as in wheat). The flowers of the bamboos, while on the whole conforming to the grass type, exhibit many small differences in different species. In some kinds, as in *Arthrostylidium longiflorum*, the inflorescence resembles a bunch of ears of wheat; in others, as in *Bambusa vulgaris*, the flowers are packed into round clusters, as shown in Fig. 3; in others, as in *Chusquea simpliciflora*, they are in threes and fours, each flower hanging by a separate slender stalk. The seed generally resembles oats or wheat, but in some species it takes the form of a berry, not unlike the seed of our familiar pimpernels. In the species known as *Melocanna* the fruit is exceptionally developed, often attaining the size of a largish pear. Some species flower and die down annually; others flower annually, but live on; as a rule, the bamboo grows for many years without flowering, and then suddenly bursts into bloom. From the fact that the number of years between the sowing of the seed and the flowering of the plant varies, and that in some years nearly all the bamboos in a given district flower simultaneously, it would seem as if the blossoming does not take place at any prescribed age, but may occur at any period after the plants reach maturity, when a favourable season supervenes. It used to be thought that after the general flowering of the bamboos throughout a district all the plants died, but this view proves to be incorrect. The flowering shoots usually die, and during the flowering the foliage almost entirely disappears, but the entire plant is not necessarily killed.

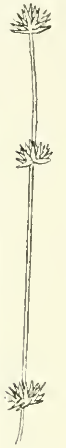


Fig. 3. Inflorescence of *Bambusa Vulgaris.*

The Chinese have a proverb that the bamboo produces seed most abundantly in years when the rice crop fails, and several curious cases of the truth of the saying have been recorded. According to General Munro, in 1812 the universal flowering in Orissa prevented a famine. Hundreds of people, he says, were on the watch day and night to secure the seeds as they fell from the branches. Another instance occurred in 1864, when there was a general flowering of the bamboo in the Soopa jungles, and very large numbers of persons came from the neighbouring districts to collect the seeds.

In most bamboos the stem is characterised by straightness, smoothness, roundness, and quickness of growth, no doubt because these qualities have as a rule proved serviceable to the plant in the struggle for existence. Light and air being necessary to the life of grass, it is manifest that in the dense vegetation of the tropics a plant which can push itself rapidly to a great height must have an advantage; and in order that growth may be rapid and the plant spring up to a considerable height without climbing, it is essential that there should be as little material as possible in the stem, and yet that it should be as strong as possible. It is difficult to imagine a stem in which these conditions would be better fulfilled than in that of the bamboo. By reason of its hollowness the amount of material is reduced to a minimum; and by reason of its cylindrical shape, its nodes, and the hardness of the outer rind, the strength of the structure is at a maximum. The growth is consequently very rapid, an increase in height of 2 to $2\frac{1}{2}$ feet having been recorded in a single day. The *Bambusa Brandisii* often measures as many as 120 feet, and is said to attain its full altitude in a few months.

But although, as a general rule, the necessities of natural selection have ordained that bamboos shall be perfectly straight and perfectly round, this archetypal form or idea (to borrow a word from Plato) does not always hold good. One species, found in Asia, is said to have crooked and even creeping stems. Another, found in Ecuador, is described by General Munro as being distinctly a climbing plant. There is a species, recently described by Mr. Thiselton Dyer, with a stem exactly square, and as well-defined as if cut with a knife. It has only lately been found in China,

where it is grown chiefly for ornament. According to Mr. Dyer, the Chinese account for its squareness in the following way. They say that in the fourth century A.D. the famous alchemist, Ko Hung, took his chopsticks (which consist of slender rods of bamboo pared square) and thrust them into the ground of the spiritual monastery near Ningpo; and then, by his thaumaturgical art, he caused them to take root and appear as a new variety—the square bamboo.

Fig. 2.—Foliage Leaf of Bamboo

The growth of plants is one of the greatest mysteries of nature, and nothing is more mysterious in their growth than their limited but very definite power of movement. How is it that some plants grow vertically upwards, like the normal bamboo, others climb and twist, others creep, and others grow in zigzag shapes? How is it that some turn towards the light, some away from the light, while others place themselves at right angles to it? And how is it that if you peg down the young stem of a vertically growing plant it will bend upwards beyond the peg? * No doubt the proximate cause is natural selection; they do these things because they have found them advantageous. But this does not tell us by what mechanism a plant is enabled to keep on growing in the particular direction which it finds advantageous. We know that when a plant bends in a given direction, the cells on the convex side of the bend are more "turgescent," that is, more distended with sap, than those on the concave side, and that the increased turgescence of the former is followed by increased rapidity of growth; but what causes the distribution of turgescence in the cells has not been clearly made out. It seems probable, however, that when a shoot is growing in its proper and natural direction, the chief force which guides it and enables it to maintain that direction is the force of gravitation. To this force the growing portions of a plant are extremely sensitive. Consider, for example, the case of a vertically growing shoot. Whenever it is accidentally bent the force of gravity must evidently act upon the portion above the bend, tending to curve it still more, and causing a strain in the material of the stem. The plant in some mysterious way is aware of this strain, and the cells of the lower side of the bent portion are stimulated to increased turgescence as compared with those of the upper side, so that the under side would grow faster; and, as the plant would turn upwards in consequence, any deviation from the perpendicular would tend to correct itself. Similarly a shoot which grows horizontally is led by the same stimulus of gravitation to rectify any departure from a horizontal position. Gravitation, then, does not *cause* the bending when a displaced shoot endeavours to regain its normal direction, but serves merely as a guide. By its means the plant is made aware (so to speak) that it has been displaced, and takes measures accordingly. If the force of gravity were absent, the shoot would go on growing in any position in which it might happen to be placed. This may be proved by causing a growing seed to revolve slowly round a horizontal axis, so that at every revolution the force of gravity may act upon it equally in all directions. When a shoot is grown in these conditions, it is found that its power of correcting deviations from any particular line of growth is lost. Similar reasoning applies to the action of light on plants, but, as above stated, we do not know why it is that plants respond to the stimulus of light or gravity; we only know that as a matter of fact they do so.

[* A most remarkable substance called Tabasheer is occasionally found within the joints of Bamboo which have been stunted in their growth. From time immemorial it has been used as a drug, and seems to have been introduced into Europe by Arab physicians, who gave it its peculiar name. It has the smallest refractive index of any known solid, and seems to be a colloidal (that is, non-crystalline) form of silica, containing air so intimately mixed with the silica that the vesicles containing the air cannot be seen under the microscope. Sir David Brewster was the first to discover the peculiar physical properties of Tabasheer; he found that its refractive index was *less than that of water*, varying from 1·1111 in some yellowish specimens of Tabasheer from Vellore, to 1·1825 in some whitish Tabasheer from Nagpore. It is never perfectly clear, but always has an opalescent appearance, probably due to the scattering of light by small vesicles of air. Mr. Thiselton Dyer says that it is always found on the *floor* of the joint, except when the Tabasheer-bearing joint leans over, when it is always found on the lower wall.—A. C. Ranyard.]

Notices of Books.

A Manual of Palæontology for the Use of Students. By Henry Alleyne Nicholson, M.D., D.Sc., F.R.S., &c., and Richard Lydekker, B.A., F.Z.S., &c. (William Blackwood & Sons, Edinburgh and London. 1889.) Palæontology, or the study of fossil animals and plants, is every year attracting a greater number of devotees, and among them are found not only the geologist, to whom some knowledge of the organisms which he meets with in the various strata is a matter of necessity, but also the biologist, who finds that many of the problems presented to him in his study of living creatures are elucidated by the investigation of extinct forms. There is still a third class, who make Palæontology their special work, not that they regard it as a science distinct from Biology, but rather as one of its larger branches, demanding for its cultivation all the scientific energy of a lifetime; at the same time they are well aware, or should be, that the key by which fossil mysteries are to be unlocked is a sound knowledge of the structure of living forms.

By all these students the third edition of Dr. H. A. Nicholson's *Manual of Palæontology*, which has just been issued, will be gladly welcomed. The fact that it has been found necessary to enlarge the work from less than 1,000 pages to upwards of 1,600 pages, and at the same time to use smaller type, is in itself an indication of the wide field which it covers. The book is now practically a new one, having been entirely re-written, and the portion treating of the Vertebrata, which occupies the greater part of the second volume, is the work of Mr. R. Lydekker, whose writings on fossil mammals and reptiles are as well known as are those of Dr. H. A. Nicholson on many groups of the Invertebrata. This division of labour, supplemented, as the authors acknowledge, by assistance from several specialists, greatly enhances the value of the work.

The reader who is not well versed in geology should read carefully the introductory chapters dealing with the sedimentary rocks and the conditions under which animal and vegetable remains have become embedded, and are

now found, constituting, as they do in many cases, a large proportion of the stratum in which they are preserved.

No classification of the animal kingdom can be regarded as more than a temporary convenience, for the rapid advance of biological knowledge will soon render some modification necessary. It is not surprising, therefore, to see important changes in the tabular view of the animal kingdom given at page 87. The sponges, having been shown to possess a more complex organization than is found in any true Protozoan, are placed in a separate sub-kingdom, the *Porifera*, thus keeping them distinct from both Protozoa and Cœlenterata. The Ascidians, or Tunicata, are now placed next to the Vertebrata. The Odontornithes or Toothed birds of North America are no longer kept as a distinct group; but those with a raft-like breast-bone are placed in the Ratitæ, and those with a keel to the breast-bone are included in the Carinatæ.

Another change, of a different character, but of no little importance, is the use of black letters and varied types for the headings and different groups; by this means the eye is much assisted, and the arrangement is more clearly impressed on the mind.

In a work dedicated especially to fossil forms, space could not be spared for a very full description of recent types; nevertheless, the authors have given such an account of the general structure of each group that the subsequent descriptions of the different forms are perfectly intelligible.

It is pleasing to find that Dr. Nicholson is not one of those who are given to change; at least, he has retained the time-honoured and expressive term Lamellibranchiata, rather than use the less satisfactory name which has obtained favour with some Malacologists. The Ammonitidæ are at present in a transitional stage, and much work has yet to be done before their grouping can be settled. The *Ammonites*, however, are among the most important fossils found in the Secondary rocks, for the determination of zones of life, and have been used for this purpose with good results in marking the lesser divisions of the Lias and other formations.

The restorations of ganoid fishes given in the early part of the second volume are very instructive, and being mostly from the hands of masters in Ichthyology may be depended upon as embodying facts of nature; more especially may be noted the figures of *Pterichthys*, of *Chondrosteus*, and of *Palæoniscus*, which are the result of much patient work on the part of one of our most eminent palæichthyologists, Dr. R. H. Traquair.

Mr. Lydekker has been much occupied of late among the fossil Reptilia, and we here find an embodiment of his own labours and those of other workers both in this country and abroad. The discovery some few years ago of almost perfect skeletons of iguanodons in the Wealden of Belgium, and their exhibition in the Brussels Museum, lent a new interest to the more fragmentary remains found in Britain, some of which belong to forms identical with the Belgian species. It is, however, in America that the most remarkable dinosaurs have been found, some of them being of gigantic size. According to Prof. Marsh, *Brontosaurus* was about 50 feet in length, with a footprint covering nearly a square yard, while its weight must have been more than twenty tons. Another of these creatures, named *Atlantosaurus*, seems to have been even larger than this. Evidence of forms allied to some of these American giants, but apparently not so large, has been found in the Wealden of this country.

The remains of fossil birds are not numerous, but some have an exceptional interest. The *Archæopteryx*, from the lithographic slates, remains the oldest, as it is the most primitive type of bird yet discovered. Additional evidence has of late years been forthcoming that gigantic birds, equalling in size some of the larger forms of the New Zealand *Dinornis*, lived in Britain, as well as on the Continent and in North America, in early Eocene times.

The genus *Microlestes*, as represented by isolated teeth from the Trias of Würtemberg and of England, has for long been the only known mammal from beds of so early a date; but Sir Richard Owen has now described a remarkable skull, from beds of about the same age, in South Africa, which he has named *Tritylodon*. This has multitubercular molars, accompanied by large incisor teeth, and it is believed to have belonged to a low type of mammal.

Special attention is directed by the author to the genealogy of the horse, as one of the best instances of evolution among the higher mammals which has yet been worked out. The gradual changes in the pattern of the teeth and the increase in the number of digits, are traced from the recent horse with one functional toe and two splint bones, through *Hipparion* with its three digits, two of which are small, and *Anchitherium*, with three digits all reaching the ground, to *Hyracotherium*, with its four functional digits of approximately the same size, the last-named animal occurring in the lower Eocene.

It is impossible here to discuss the hypothesis advocated by Mr. Lydekker, that the horses of America and Europe have been independently developed in the two countries along parallel but distinct lines; but this certainly seems less in accordance with known facts than does the supposition that from early Eocene times until the Pliocene period there were frequent, if not continuous, opportunities of intercommunication between the northern parts of Europe, Asia, and America.

The ponderous *Dinocerata* from the Eocene of Wyoming, are remarkable mammals of a primitive type, seeming to combine the characters of several living forms. The skull of one of these, the *Uintatherium*, has been chosen as an illustration for the cover of the second volume; and certainly its form is striking enough, with its six horn-like protuberances from the frontal and nasal regions, and its enormous canine teeth, reminding one of those in the carnivorous genus *Machærodus*.

The fourth part of this manual, which treats of Palæobotany, has been much improved; but it professes to be only a general summary of the subject, and is not treated in so detailed a manner as the previous parts.

The work is throughout profusely illustrated, and the figures are for the most part good and well chosen; but some of them are far from being creditable productions, and it is a pity they have been allowed to mar the general excellence of the work. As an example of what woodcuts may and should be, see that on page 1265, and for an example of what they should not be, see page 1283. A few of the figures are misleading, such, for instance, as the mouth of the sturgeon on pages 916 and 975, and the old figure of a Pterodactyl, on page 1203, with four clawed digits to the manus, will lead to more errors than will be rectified by the explanation and correction in the text. These defects, however, are small when compared with the general excellence displayed throughout the two volumes, which contain a large amount of reliable information, brought together in a convenient and readable form; information which would otherwise have to be sought in many separate treatises, often difficult of access. The work, therefore, may be confidently recommended to all who desire a thorough insight into the study of fossils; and moreover, although ten years have elapsed since the publication of the previous edition, this remains the only English manual of Palæontology.—E. T. Newton.

A Naturalist Among the Head Hunters; being an Account of Three Visits to the Solomon Islands in 1886, 1887, *and* 1888. By C. M. Woodford. (London: Philip & Son, 1890.) There are many collecting crazes, all of which probably tend to weaken the moral sense. For the ardour of the collector, whether he covets his neighbour's skull or coins or rare Elzevirs, makes him not too careful as to the means whereby the end is reached. We must not therefore judge too harshly or hastily the form which the passion takes among the Solomon Islands' natives and other barbaric peoples, with whom the main business of life appears to be the taking of each other's heads. For head-hunting, although connected with cannibal or sacrificial practices, is often independent of both, being largely

Group of Sago Palms.

due to the desire to collect proofs of skill and power, as, among ourselves, the hunting man adorns his hall with the trophies of the chase. Thus it is that among the natives of the Solomon Islands expeditions are made in large and well-built canoes, by parties numbering thirty or forty men, armed with spears and rifles, who pounce upon the coast villages, and either cut off the heads of the inhabitants or defer that operation till a new canoe is launched or a collection needs additions. The Solomon Islands were discovered in 1568, and were named after the wisest of men by their shrewd discoverer, Mendaña, a Spaniard, with the design that his countrymen, supposing them to be the source whence Solomon obtained his gold, might be induced to colonise them. They were lost sight of for two hundred years, and their existence questioned until their re-discovery towards the end of last century. They are, for the most part, densely wooded, and peopled with tribes between whom internecine strife is chronic. They are full of interest to the geologist and the naturalist, yielding evidence to both that they have not been connected with any continent. Their coasts are fringed with the useful coco-nut palm, traffic in the fruit of which brings out the smartness of the natives, who are always ready to make out that they do not know how many coco-nuts make ten; as a general rule it is seven and a half with them, but sometimes it is only six! Further inland plantations of sago palms flourish in the swampy ground, yielding one crop of nuts and then dying, the once fruitful trunk becoming nothing "but a collection of rotten brown fibres." The main object of Mr. Woodford's visits was to

Coco-nut Palms. View on the Seashore.

collect the fauna of the islands, in which he was successful, his additions to our knowledge having much interest in themselves, as well as value in their bearing upon the problems of geographical distribution. Among the most remarkable of these additions are a rat which measures two feet from nose to tip of tail, and two genera of bats which form a very important link in the life-history of the Chiroptera, while among more familiar forms of those regions are the great coco-nut robber crabs, monster lizards five feet long, and gorgeous butterflies measuring nine inches across the wings. The natives themselves are typical examples of the result of occasional intercourse with the whites, the varnish but thinly con-

cealing the savage. Fashion sways their lives somewhat, for turkey-red calico is not always worn, sometimes navy-blue being *en règle*, while the approved shape and colour of pipes varies, the natives refusing to exchange coco-nuts for white pipes when the fashion runs on red ones! Their religion manifests the common features of that of barbaric peoples, being a species of ancestor-worship, with belief in spirits, mostly of malign nature, everywhere, to whom propitiatory offerings are made. One hopeful sign among them is that they more and more incline to conceal the real motive of their head-hunting voyages, and will say that they are going for turtle-shell. But tribe after tribe has been effaced, and the extinction of the rest is certain. Mr. Woodford both prefaces and concludes his book with apologies for lack of literary style. They are needless, for his narrative is written in a direct, straightforward way, with honest ring in the words that will not fail to commend it as a worthy addition to the growing body of literature of travel in Melanesia. The value of the book is increased by remarkably good reproductions of excellent photographs taken by Mr. Woodford, as evidenced by the two specimens which the publishers kindly allow us to print; by three clear maps, and by a fairly full index.

Idyl's of the Field. By Francis A. Knight. (Elliot Stock.) Under this title the gifted author of "By Leafy Ways" has collected into book form a second series of reprints from the *Daily News*. In a number of exquisite word-pictures Mr. Knight vividly portrays some charming country and seaside scenes taken chiefly from the West of England. He looks upon nature with the eye of a poet, and in refined and graceful language tells out the thoughts she inspires. The ever-varying phases of bird- and plant-life are specially attractive to him, and his musings are interspersed with antiquarian touches that stir the reader's imagination and help to link the present with the past in a most delightful manner. His keenness of observation and his full sympathy with the calmer and quieter side of nature are evident throughout; not a rustle among the withered leaves, not a tiny footprint on the freshly-fallen snow, or on the sands round the margin of the secluded pool, but is eloquent to him of secrets that can be revealed only to such sympathetic spirits. No better exemplification of the old truth, that the eye sees only what it brings the power to see, could be found than in these pages, which may profitably be pondered over by any who desire to improve their mental vision. There are several beautiful photogravures and other illustrations, which are in complete harmony with the general tone of the book, and which combine to make it a dainty gift-book for all lovers of nature.

The Butterfly: its History, Development, and Attributes. By John Stuttard. (T. Fisher Unwin.) This booklet originated as a paper read before the Rochdale Literary and Scientific Society. It indicates a good deal of thoughtful reading on the part of an enthusiastic student of nature, who, in what has evidently been a labour of love, has put together in a somewhat unconventional manner a variety of interesting matter bearing on the structure, habits, and uses of butterflies. May we suggest that, if Mr. Stuttard could have prevailed on some scientific friend more skilled in the use of technical terms to do a little "editing" for him, some verbal errors, such as Anthropoda for Arthropoda, chrisos for chrysos, tarsis for tarsus, might have been avoided, and a laudable effort thus rendered more acceptable.

Thermo-electricity. By Arthur Rust. (E. and F. N. Spon. London: 1889).—In this little book another attempt is made to solve the great question, "What is electricity?" The author defines electricity as "a mode of motion, a flow of molecular vibrations produced by the friction of molecules against molecules." The subsequent explanation shows that he differs considerably from other electricians in his conception of the nature of electricity. In the endeavour to establish his position he describes a number of experiments with thermo-electric couples, iron being taken as one of the metals and a compound of zinc and antimony as the other. We could have wished that fuller details of these experiments had been given; for instance, the temperature at the point of junction between the zinc alloy and the galvanometer wire, the resistance of the circuit, and the interval of time (if any) between the application of the heat and the reading of the galvanometer. Full details are the more necessary because Mr. Rust controverts the accepted thermo-electric law that the strength of the current depends on the difference in temperature between the two junctions.

Zenographical Fragments. I. By Stanley Williams, F.R.A.S. (Mitchell & Hughes. London, 1889.) This is in no sense of the word a *popular* work, but one by an expert for experts. Undeterred by the low altitude of the planet in 1886-87, Mr. Williams set to work to make a detailed and systematic examination of all the markings of Jupiter visible in his telescope on every available occasion. He employed a 6½. in Calver silver-on-glass reflector, armed with a single lens giving the comparatively low power of 170, which he found gave the best views of the surface of the planet in its then great southern declination. His object was twofold: to fix, by the method of transits, the longitude of the various spots, and to make detailed observations of the magnitude, brightness, and appearance of every definite marking on the disc. Seventy sketches were made, and an elaborate chart of the markings on Jupiter, reduced to the date of opposition, April 21, 1887, forms the frontispiece of the book. Of course, as Webb remarks, owing to spherical foreshortening large portions of the disc near the poles must remain for ever unknown. The work is divided into seven sections, treating of the instrument employed, the behaviour of individual markings, on their relative altitudes, the mean rotation of spots situated in different latitudes, the apparent repellent influence excited by the great red spot, the colour of which was first noticed in 1868, &c. The illustrations are numerous. The work forms a most excellent monograph of its subject, and is appropriately dedicated to the memory of Schröter.—H. S.

Profitable Fruit-Growing. By John Wright, F.R.H.S. (E. H. May.) The Fruiterers' Company, in order to encourage the culture of fruit amongst cottagers, last year offered a gold medal and prize of twenty-five guineas for the best practical essay on the subject. Mr. Wright was the successful competitor with the present essay. It contains much useful advice, and gives in plain language just the information required as to the planting, pruning, and general management of those kinds of fruit that can easily and profitably be cultivated on small holdings. It is copiously illustrated, and the idea of *profitable* culture is kept clearly in view throughout. Cottagers and other holders of small plots should avail themselves of the help of this essay if they wish to know how to make the most of their ground.

The Cultivated Oranges and Lemons, &c., of India and Ceylon. By E. Bonavia, M.D., Brigade Surgeon, Indian Medical Service. (W. H. Allen & Co., 18.0.) Dr. Bonavia has devoted many years to the study of the

numerous varieties of oranges, lemons, and citrons growing in India, with a view of encouraging the development of what he believes might be made a very important industry, in a country where labour is cheap, as compared with California and the Mediterranean littoral, and the climatic conditions are in no way inferior. It seems that many of the Indian varieties grow with little or no artificial irrigation. They are mostly propagated from seed, sown thickly in a seed nursery on prepared earth, till the plants are about four inches high, when they are transplanted and placed eight or nine inches apart, and allowed to grow till they are four years old; they are then again transplanted to the orange gardens where they are intended to grow. The book, though intended for specialists, contains a great deal of interesting information for others besides professional orange-growers. It is accompanied by an Atlas of over 250 plates, showing a remarkable variety in the forms and sizes of fruit; and Dr. Bonavia has given an excellent Index.

Our Eyes, and How to Preserve them from Infancy to Old Age. By John Browning, F.R.A.S. Eighth Edition. (Chatto & Windus.) This is a very useful little book, explaining in simple language, and by means of very numerous illustrations, facts which ought to be widely known in this age of over-taxed eyes. Besides the ordinary explanations as to short sight and astigmatism, and other physical defects of our eyes, it contains some sensible suggestions as to the proper fitting of spectacles, and minor matters which are too little attended to.

The Educational Annual. 1890. Compiled by Edward Johnson. (George Philip & Son.) This is a useful compilation, putting into small compass a large amount of information on all kinds of educational matters pertaining to all grades from the elementary schools to the universities. The chief deficiency we notice is in connection with secondary education. While good lists, with abundant details, are given of the proprietary and endowed schools, the private schools are almost entirely ignored. And yet many of these, whatever may have been their condition in past years, are now doing excellent educational work, as is testified by the extent to which they figure in the University Local Examinations.

We regret to announce the death of Prof. Montigny, well known for his researches on the scintillation of stars, on the 16th of March. He died at Schaerbeek, near Brussels, after a short illness. He was born in January 1819, and was consequently in his 72nd year.

The photograph of a sun-spot given in the February number of Knowledge was enlarged from a photograph taken by M. Janssen on the 28th of June 1885. On the scale of the enlargement the sun's disc would be 1·40 meters in diameter.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

ASTRONOMICAL PHOTOGRAPHY.

To the Editor of Knowledge.

Dear Sir,—I beg you to accept my thanks for a copy of Knowledge containing your interesting article on stellar parallax, and Mr. Sadler's valuable collection of results, the most complete that I have seen.

Your criticism of the accuracy of results obtained from photographs is timely, since this method needs as careful examination as any other. There is a tendency at present to extol the exactness of the photographs without stopping to measure and discuss them, and we already have a demand for fire-proof buildings in which to stow the plates. Thus astronomy is in danger of being reduced to the condition of meteorology, where a million observations more or less are of no account. In 1874 I was shown a photograph of Venus *in transitu*, with the remark, *One photograph is sufficient!* as though a few photographs would settle for ever the distance of the sun The discussion of the American photographs of the transits of 1874 and 1882, nearly two thousand in number, gives for the probable error of the position of Venus from a single plate about half a second of arc; that is, the photographic plate has approximately the same degree of accuracy as an observation with a meridian circle. Our photographs of these transits are beginning to deteriorate, and it is well that the plates have been measured and the results secured.

Still, it appears to me that the photographic method does furnish certain real advantages for the determination of stellar parallax. These come largely, I think, from the fact that we have on the same plate stars of comparison in various directions and distances, and that by means of these we are enabled to eliminate constant errors, which are the most dangerous in this kind of work. The heliometer presents similar advantages, but the photographs have over this instrument the advantage of much greater ease in observing. It remains to be shown what degree of accuracy can be obtained from recent photographs in measuring relative positions. The results published from the Potsdam observatory indicate an accuracy equal to that of the best micrometrical work.—Yours truly,

U.S. Naval Observatory, Washington.
Feb. 27, 1890. Asaph Hall.

[I fully concur with Prof. Asaph Hall as to the advantages offered by the photographic method, if the probable error of a single measure, made on a photograph, can be relied on as comparable with the probable error of a single eye observation, and I do not doubt that the average deviation from the mean of series of measures made on photographs have been found to be comparable with the average deviation from the mean of eye observations; but we can only assume that the average deviation from the mean is the probable error of a single observation when all systematic errors are eliminated. The most practical test one can apply to determine whether all constant sources of error have been eliminated is the comparison of measures made by independent observers on different photographs. When several such measures confirm one another within the limits of probable error claimed, my faith in the photographic method will increase.—A. C. Ranyard.]

To the Editor of Knowledge.

Sir,—May I be allowed, as an old variable star observer, with all deference, to suggest a doubt whether the diagram in your March number, with its marked angularities, presents a true picture of the light curve of S. *Ursæ Majoris*? The Rousdon observations seem to me to be too loosely scattered to enable one to distinguish with precision between accidental errors of observation and real points on the curve.—I am, Sir, yours faithfully,

George Knott.

Knowle's Lodge, Cuckfield, March 21, 1890.

[One would naturally listen with deference to any criticism from Mr. Knott with respect to the observation of

variable stars. But I think that he has in this instance mistaken Mr. Peek's meaning in supposing that the sharp irregularities of the Rousdon curve are intended to represent the true variations of the star's light. Mr. Peek has simply joined the points corresponding to the brightness of the star at the dates of observation by straight lines—without attempting by freehand drawing to round off any of the angles. Such smoothing of curves must always be a matter of guess-work, and it is probably more desirable to let the diagram represent as exactly as possible the means of the estimates of brightness made at each of the various dates of observation.

The great question of interest is whether it would be possible to conceive of the irregularities shown as only due to accidental errors of observation. It seemed to me that Professor Pickering's observations of *S. Ursæ Majoris*, as well as those made at Rousdon, indicate that there are greater irregularities in the estimates of the star's brightness than can be accounted for by errors of observation in comparing the brightness of the variable with other stars in its neighbourhood, whose brightness would be equally affected with that of the variable by changes from night to night in the clearness of the atmosphere. The question is, however, one on which further observations are much needed.—A. C. Ranyard.]

DIVISIBILITY BY 37.

Dear Sir,—In your March issue Mr. T. S. Barrett has mistaken how to apply the test. Let me show him. His first number was 262774259. Take the sums of every third figure $9+4+2=15$; $5+7+6=18$; $2+7+2=11$. Now take 11 from $18=7$; and 11 from $15=4$, and since $74=37$ M, the given number also$=37$ M.

Again, take 973112691, his other number.

Here the sums of every third figure are 6, 17, 16, respectively, and 16 from $17=1$ (ten), and 16 from $6=-10$. Then since $10-10=0$, the given number$=37$ M.

The mathematical proof of the test is unsuited to your columns, but I shall be happy to forward it to anyone interested. I have constructed simple tests for divisibility by any number.

$r^n \pm r^{n-1} + r^{n-2} \ldots + r \pm 1$ or its factors. There are several tests for the number 7, one of which is easier than the above. My object in the February number was not to give tests of divisibility, but to show the connection between the periodicity and the divisibility. There are other points I should like to have touched upon did your space and the pressure of my business permit.—Yours faithfully, Robt. W. D. Christie.

Wavertree Park College, Liverpool,
15th March 1890.

P.S.—I take this opportunity of correcting a clerical error on p. 73, lines 23 and 25 from bottom. Instead of $9(p-1)2$ and $P(p-1)2$, read $9(q-1)2$ and $P(q-1)/2$.

MAGNITUDE OF STARS.

To the Editor of Knowledge.

Sir, Referring once more to the diagram of the distances of the fixed stars in your February issue, I should like to ask if it is possible to infer what magnitude of star our own sun would correspond to, if it were placed at the distance of *α* Centauri, or Sirius.

Thanking you for your answer to my former question,

I remain,
Yours truly,
J. Shaw.

Tynron, Scotland,
12 March 1890.

[Various determinations of the light of the sun as compared with the light of the full moon, and the light of the moon as compared with that of stars, have been made. Huyghens, in 1698, compared the light of the sun with that of Sirius by allowing the light of the sun to shine through a minute hole. According to his experiments, the sun gives 756,000,000 times the light of Sirius. Wollaston, in 1829, compared the image of the sun and of a lamp reflected in a silvered bulb of glass with the light of Sirius. According to these experiments, the sun gives 20,000,000,000 times the light of Sirius.* Steinheil, in 1836, from comparisons between the light of the sun and moon, and that of Sirius, gave the ratio as 3,840,000,000. In 1861, Bond determined the relative light of the sun and moon by comparing their reflections in a glass globe with that of an artificial light. Combining his measures with the comparisons of the moon and Sirius by Herschel and Seidel, he deduced the ratio 5,970,500,000.† In 1863, Clark found that, if the sun was removed to 1,200,000 times its present distance, and Sirius to 20 times its present distance, they would appear equally bright, and equal to a sixth-magnitude star. This corresponds to a ratio of 3,600,000,000 between the light given by the sun and Sirius. Prof. E. C. Pickering, in his remarkable paper on Algol, published in the proceedings of the American Academy for 1880, computes the brightness of the sun, measured in star magnitudes from Huyghen's measures, as 22·2 magnitudes brighter than Sirius; from Wollaston's measures, 25·75 magnitudes; Steinheil's, 23·96; Bond's, 24·14; and Clark's, 23·89; from which Prof. Pickering assumes (taking Sirius as of the −1·5 magnitude) that the light of our sun, measured in stellar magnitudes, may be considered as corresponding to about minus twenty-five and a half magnitudes of the stellar scale.

The scale of star magnitudes has been so arranged that if any star were removed to ten times its present distance (where it would give a hundredth part of its present light) its brightness would be decreased five magnitudes. Consequently, if the sun were removed to a hundred thousand times its present distance (*i.e.* to a distance of about $1\frac{1}{2}$ light years), it would, according to Prof. Pickering's estimate, appear about one magnitude less bright than Sirius, and at the distance of *α Centauri* it would not differ greatly from a star of the first magnitude.—A. C. Ranyard.]

THE MEANING OF A MINUS PARALLAX.

Sir,—Will you kindly explain how a minus parallax is obtained, and what it means?—Yours faithfully,

J. F. King.

[In the case of an absolute parallax, it must be taken to mean that there is some systematic error which vitiates the observations. But in the case of a relative parallax it may mean that the comparison star or stars are nearer than the star whose shift in the heavens is measured.—A. C. Ranyard.]

To the Editor of Knowledge.

Dear Sir, With regard to the list by Mr. Sadler following your own most interesting article on stellar parallax in the number of Knowledge for February,

* Phil. Trans. cxix. 28.

† Mem. Amer. Acad. viii., N.S., p. 298.

there are two points on which I should like to address a few words to you. (1st.) The various cases where two or more distinct values are given for the parallax of a star, the observer, method, date, publication, &c., being the same, and there being nothing to show that a redetermination has been made, as in the case of γ Cassiopeiae, where the values (neglecting probable errors) of 0″·14, +0″·007, 0″·025, and +0″·050 are given. Are these to be regarded as four distinct determinations, each from observations extending through one year? In the case of Polaris, the values + 0″·073 and + 0″·079 are given. From a consideration of your note on p. 62, I conclude that Mr. Sadler's list, though in type, was open for new results at least as far as November 7, 1889; yet in the number of *Nature* for that date (vol. xli., No. 1045, p. 19), in mention of Professor Pritchard's *Researches in Stellar Parallax*, the value given for Polaris is +0″·052±0″·011; and as far back as July 5, 1888, it is stated in *Nature* (vol. xxxviii., No. 975, pp. 227-8), with regard to the Oxford observations, that the determinations of 61[1] and 61[2] *Cygni*, *μ Cassiopeiae*, and *Polaris* "may be regarded as nearly completed," and the result for Polaris is given as +0″·052±0″·0314, of which I take the above-mentioned result of +0″·052±0″·011 to be the completion. Adding this value to the two given in the list, we have for Professor Pritchard's results the values +0″·073, +0″·079, and +0″·052. To take an example other than the Oxford observations, I may refer to p. 66, where Brünnow's (1870-71) result for Vega is given as +0″·131 and +0″·188. *β* and *α Cassiopeiae* are also cases in point, and for these two stars and *γ Cassiopeiae* the same date, viz. 1888, is given as the time of observation, from which I understand (for in other cases the number of years is given through which the observations extend) that these stars have only been observed by Professor Pritchard through one year; yet if this be so, how have the widely differing determinations been obtained? I venture to hope that if the points admit of a brief explanation Mr. Sadler or yourself will be good enough to devote a few lines to the subject.—Yours most faithfully,

"γ Draconis."

Galashiels, N.B.

[Your correspondent (who, I regret, does not give his name) is perfectly correct in his criticism. There is a difference in the results which have been published by Professor Pritchard in the *Monthly Notices* and in the Oxford observations. The difference between these and the results communicated to *Nature* (before the publication of the Oxford determinations) may be due to the fact that in the case mentioned of *Polaris* the parallax as derived from only one of the comparison stars is given. Possibly Professor Pritchard may not be himself responsible for this. It is one of the disadvantages of premature announcements that incomplete results, which subsequently receive modification, are published. In the case of γ Cassiopeiae, 0″·14 is misprinted in my paper for 0″·014. The same stars are not always employed in the two determinations. As I have said above, I presume that the writer of the articles in *Nature* has taken the parallax of Polaris as determined from the brightest of the four stars observed at Oxford (B. D. +88°, No. 4, 6·7 mag., in *Monthly Notices*, 6·84 mag. in Oxford University observations). The parallax of Polaris from the star is given in the *Monthly Notices* as +0″·0429±0″·015, and in the Oxford University observations as +0″·052±0″·011. In the case of *Vega*, the differences in Brünnow's results are due to his accepting or rejecting certain constant errors. "γ Draconis" must refer to the original papers for information of this kind, which it was impossible to give in the limits of a magazine article.—H. Sadler.]

THE FACE OF THE SKY FOR APRIL.

By Herbert Sadler, F.R.A.S.

Sun-spots have been rare of late, but at the time of writing a fine double one is entering on the solar limb. The Zodiacal light should be looked for in the absence of moonlight during the second and third weeks of the month. Mercury is invisible during the first half of the month, being in superior conjunction with the sun at 8h. a.m. on the 9th. During the latter half of the month the planet will be more favourably placed, setting on the 23rd at 8h. 42m. p.m. with an apparent diameter of 6″, and a northern declination of 19°, and on the 30th at 9h. 24m. p.m., 2h. 5m. after sunset, with an apparent diameter of 7″, and a northern declination of 22¼°. While visible he passes from Aries into Taurus, being about 20′ *s.p.* the 4th magnitude star δ Arietis on the 23rd at 8 p.m.; at the same hour on the 25th he will be about 6′ *s.f.* the 6th magnitude star 65 Arietis, and on the evening of the 28th about 2° south of the Pleiades. Venus is an evening star throughout the month, setting on the 1st at 7h. 27m. p.m. with a northern declination of 7¾°, and having a slightly gibbous disc subtending an angle of 10″; on the 30th she sets at 9h. 0m. p.m. with a northern declination of 20° and an apparent diameter of 10½″. During the month she passes from Pisces through Aries into Taurus, but without approaching any conspicuous star very closely. Mars is an evening star, rising on the 1st at 11h. 50m. p.m. with a southern declination of 21° 21′, and an apparent diameter of 14″; on the 30th he rises at 10h. 12m. p.m. with a southern declination of 22° 39′, and an apparent diameter of 18½″. During the month he passes through portions of Scorpio and Ophiuchus, but does not approach any naked-eye star very closely. He is stationary at midnight on the 22nd. Pallas is in opposition to the sun on the 29th, when she is at a distance of 178¾ millions of miles from the earth, and appears as a 7·4 magnitude star. Her diameter is given, from photometrical considerations, by Argelander at 158 miles, Pickering 167, Stone 171. Lamont, from measurements of the diameter of the disc, found 630 miles; Schröter exceeded all bounds by giving one of 2,030 miles. During the month she passes from Serpens into Corona Borealis. On the night of the 3rd, about midnight, she is 4′ due north of the 6·0 magnitude star τ[5] Serpentis, and on the 8th about 15′ *n.f.* to the 6·0 magnitude star τ[7] Serpentis. On the night of the 10th she is 27′ due south of the 4½ magnitude star ι Serpentis. Jupiter is a morning star, rising on the 1st at 3h. 37m. a.m., with a southern declination of 18¾°, and an apparent diameter of 33½″. On the 30th he rises at 1h. 54m. a.m. with a southern declination of 18°, and an apparent diameter of 36½″. The following phenomena of the satellites occur while the planet is more than 8° above, and the sun 8° below the horizon. A reappearance from eclipse of the third satellite at 4h. 17m. 36s. a.m. on the 2nd. An egress from transit of the third satellite at 4h. 6m. a.m. on the 13th. A reappearance from occultation of the second satellite at 3h. 29m. a.m. on the 24th, and an ingress of the first satellite on the disc one minute later. An ingress of the shadow of the third satellite at 3h. 17m. a.m. on the 27th. Jupiter is in Capricornus throughout the month. On the mornings of the 5th and 7th a very pretty double star, 6½ and 7·0 magnitudes, 15½″ apart, will be noticed in the field of view a little north of the planet. On the morning of the 10th a 6½ magnitude star will be about 7′ north of the planet. On the morning of the 15th the 6th magnitude star 19 Capricorni will be about 2½′ north of the planet. Saturn is still in a favourable position for observation, rising on the 1st

at 2h. 4m. p.m. with a northern declination of 13° 54′, and an apparent diameter of 19″ (the major axis of the ring-system being 44″ in diameter, and the minor 8½″). On the 30th he rises at 0h. 7m. p.m. and souths at 7h. 25m. p.m. with a northern declination of 14° 5′, and an apparent diameter of 18¼″ (the major axis of the ring being 42″ in diameter, and the minor 8″). On April 8th, at 8h. p.m., Dione and Iapetus are in conjunction. At about a quarter to five p.m. on the 9th Iapetus is occulted by the ring, the disappearance being 3″ to the north, the emergence taking place in broad daylight the next day. Uranus rises on the 1st at 7h. 36m. p.m. with a southern declination of 9¼° and an apparent diameter of 3·8″. He rises on the 30th at 5h. 31m. p.m. with a southern declination of 8¾°. He is in opposition on the 14th, when his distance from the earth is about 1,620 millions of miles, and the magnitude of the planet 5·4 in the photometric scale. He describes a short path in Virgo, nearly midway between the stars 76 and 82 Virginis. Neptune has practically left us for the season. Shooting stars are fairly plentiful in April, the most marked shower being that of the Lyrids, with a radiant point in 18h. 0m. R.A. + 33° Decl. The radiant point rises on the nights of the 19th and 20th, when the maximum occurs, at 6h. 27m. p.m., and souths at 4h. 8m. a.m. The moon is full at 9h 24m. a.m. on the 5th, enters her last quarter at 10h. 53m. a.m. on the 12th, is new at 8h. 5m. a.m. on the 19th, and enters her first quarter at 4h. 52m. a.m. on the 27th. On the 5th, at 8h. 32m. p.m., the 6th magnitude star 80 Virginis will disappear at an angle of 90° from the lunar vertex, and reappear at 9h. 1m. p.m. at an angle of 145°. At 2h. 33m. a.m. on the 8th the 6th magnitude star ζ' Libræ will disappear at an angle of 112° from the vertex, and reappear at 3h. 28m. a.m. at an angle of 215°. At 0h. 58m. a.m. on the 11th the 6½ magnitude star B.A.C. 6217 will disappear at an angle of 29° from the lunar vertex (the star is below the horizon at the time), and reappear at 2h. 0m. a.m. at an angle of 250°. At 10h. 40m. p.m. on the 22nd the 5th magnitude star ι Tauri will make a near approach to the lunar limb at an angle of 219° from the vertex. At 11h. 41m. p.m. on the 24th the 6th magnitude star B.A.C. 2238 will disappear at an angle of 135° from the vertex, and reappear at 0h. 32m. a.m. on the 25th at an angle of 285° from the vertex. On the 30th, at 11h. 0m. p.m., the 4th magnitude star ν Virginis will disappear at an angle of 129° from the vertex, and reappear at 11h. 48m. p.m. at an angle of 221° from the vertex.

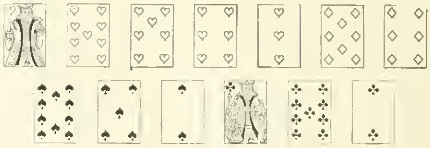
Whist Column.

By W. Montagu Gattie.

FORCING A DISCARD.

Some of the finest strokes of play at whist consist in forcing an adversary to make a disadvantageous discard. To take a simple case. Four cards being left in each hand, A, who has to lead, finds himself with the last trump, and one small card at least in two suits of which Y (his left-hand adversary) holds the second and third best, and B (A's partner) the best and a small one, while Z's cards are of no consequence. By leading out his trump A secures all the four tricks; for, whichever suit Y discards from, B discards from the other, A leads the suit from which Y has discarded, and B makes the three remaining tricks. On the other hand, if A were to lead one of his plain-suit cards instead of the trump, nothing could prevent Y from making a trick. The following hand furnishes a more complex illustration of the same principle:—

Hand No. 10.

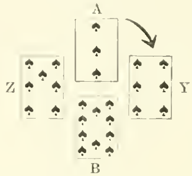


B's Hand.

Score—Three All. Z turns up the Queen of Hearts.

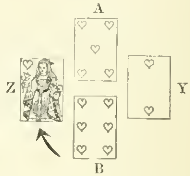
Note.—A and B are partners against Y and Z. A has the first lead; Z is the dealer. The card of the leader to each trick is indicated by an arrow.

Trick 1.



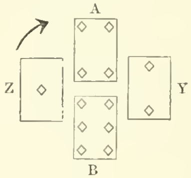
Tricks—AB, 1; YZ, 0.

Trick 2.



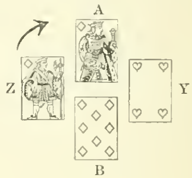
Tricks—AB, 1; YZ, 1.

Trick 3.



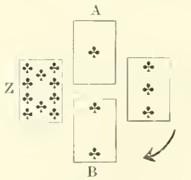
Tricks—AB, 1; YZ, 2.

Trick 4.



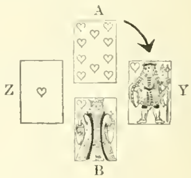
Tricks—AB, 1; YZ, 3.

Trick 5.



Tricks—AB, 2; YZ, 3.

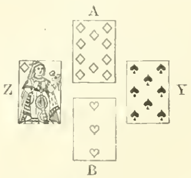
Trick 6.



Tricks—AB, 2; YZ, 4.

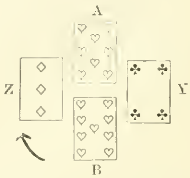
Note.—*Trick* 5.—It is quite possible that Y may have led from three clubs to the queen in preference to returning the spades up to A's strength.

Trick 7.



Tricks—AB, 3; YZ, 4.

Trick 8.



Tricks—AB, 4; YZ, 4.

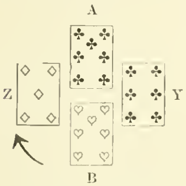
Notes.—*Trick* 7.—Y's discard shows that Z has no more spades (see trick 1), so that Z's remaining cards are four diamonds and two clubs. It follows that, if Y has three clubs left, A cannot have more than two. B himself

holds the two of spades, and consequently knows that A's three (trick 1) was not a penultimate, *i.e.* that A has only three more spades. Therefore, unless Y's lead at trick 5 was from three clubs only, A must hold the other trump.

Trick 8.—B nevertheless draws the trump. If Y holds the major tenace in spades, the game is hopeless, honours being declared against AB; but if he holds king, knave, against A's ace, queen (the only other possible case), the game may be saved by throwing the lead into his hand at the right moment, and compelling him to lead spades up to A. Continuing the clubs at this point would be fatal if the other trump should turn out to be with Y.

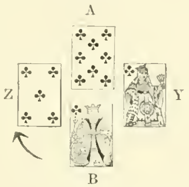
Y's discard is the best under the circumstances (see B's inference from trick 8 in the analysis given below).

Trick 9.



Tricks—AB, 5; YZ, 4.

Trick 10.



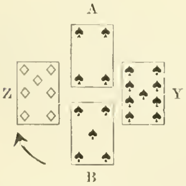
Tricks—AB, 6; YZ, 4.

Notes.—*Trick* 9.—Z probably has either queen, knave, of clubs, or knave guarded; and, if B now continues with king and another club, Z, after getting in, will force him in diamonds, obliging him, after all, to lead spades up to Y.

Y again discards a club for the same reason as before. It is, however, interesting to notice that, if he discards a spade, B must not think to place the lead in his hand by playing out king and another club; for Y will throw his queen on the king, leaving the command with Z, after which there is no way for AB to save the game.

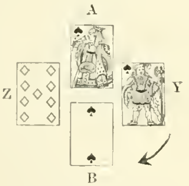
Trick 10.—It is, of course, necessary for B to dispose of his king of clubs before leading the spades.

Trick 11.



Tricks—AB, 6; YZ, 5.

Trick 12.



Tricks—AB, 7; YZ, 5.

Trick 13.—A makes the ace of spades, and AB score two by cards and win the game.

A's Hand.	B's Hand.
H.—10, 8, 5.	H.—Kg, 9, 7, 6, 3.
S.—Ace, Qn, 4, 3.	S.—10, 5, 2.
D.—Kg, 10, 4.	D.—8, 6.
C.—Ace, 8, 7.	C.—Kg, 9, 2.

Y's Hand.	Z's Hand.
H.—Kn, 4, 2.	H.—Ace, Qn.
S.—Kg, Kn, 9, 8, 6.	S.—7.
D.—2.	D.—Ace, Qn, Kn, 9, 7, 5, 3.
C.—Qn, 6, 4, 3.	C.—Kn, 10, 5.

In place of our usual elementary explanation of the play, we append an analysis of the play of B's hand and the inferences drawn by him from each trick.

Tricks.	Play.	Inferences.
1.	Plays highest card, third in hand.	A has exactly four spades: for since B himself holds the two, the three cannot be a "penultimate." Z has eight and nine of spades, or no more. Either A has ace, queen, of spades and Y has king, knave, or *vice versâ*. In any other case, one or other of them would have played an honour.
2.	Leads trumps, holding five to an honour. Opens with penultimate to show number.	Z has no more trumps, or ace of trumps and no more; or he has ace, knave, and has played a false card. For, except in these cases, he would not put in his queen, second in hand, unless he also held the king; and the king is in B's own hand.
3 & 4.	Follows suit.	Z has led from ace, queen, knave, of diamonds and at least two others. Y being void, the remaining six diamonds must lie between A and Z; and A cannot have more than two, or he would have led diamonds originally instead of spades. Therefore Z must have at least four.
5.	Plays lowest card, second in hand.	Y may have four clubs, or he may be leading from a short suit in preference to returning the spades up to A. Since A wins the ten of clubs with the ace, YZ must hold queen and knave between them.
6.	Heads the trick. He might perhaps hold up the king, for Z cannot have anything but the ace, and if the ace had been with Y he would almost certainly have put it on the ten. But this course might leave A in doubt as to the position of the king, and nothing would be gained by it, as B retains the command with the nine.	The remaining trump may be with either A or Y: for A would in either case return the ten, and Y, holding knave, eight, might prefer to cover ten with knave. YZ are out by honours unless AB can forestall them by making two by cards.
7.	Trumps adverse winning card.	A has no more diamonds, and Z has the remaining four. Y's discard shows that Z has no more spades (see inference from trick 1), and therefore Z has two clubs.
8.	Draws the losing trump, its position being doubtful. If Y has it, and if B now goes on with clubs, either Y or Z will win the third round, and B, after being forced by a club or a diamond, as the case may be, will have eventually to lead up to Y's tenace in spades.	Y is evidently in a difficulty, assuming that the tenace in spades is against him. If he discards another spade, B will be able to lead spades, to which A will play his queen as the only chance of making game; Y, after winning with the king, must lead a club; B, winning with king in his turn, will lead another spade; and A will make his ace, and afterwards the small one.
9.	Accordingly, B leads another trump. The student will find that any other line of play loses the game, whether A finesses or not.	It is now certain that Y does not hold the major tenace in spades; with ace, queen, he would secure the game by discarding from that suit. He has clearly determined to leave the protection of the club suit to Z.
10.	Leads the best club. Otherwise Y, after getting in with a spade, would dispossess himself of the lead by continuing with the queen of clubs.	Z is left with the best club. Therefore the only way of winning the game is to lead a spade, trusting to A to pass it and remain with tenace over Y.
11.	Leads a spade accordingly.	

Chess Column.

By I. Gunsberg (Mephisto).

[Contributions of general interest to chess-players are invited. Mr. Gunsberg will be pleased to give his opinion on any matter submitted for his decision.]

NOTES ON THE HABANA MATCH.

The following table will show the course of play during the match :—

Game.	Opening.	Won by, as 1st player.	Won by, as 2nd player.	Drawn.
1.	Ponziani	T	—	—
2.	Spanish...	—	T	—
3.	French	—	G	—
4.	Four Knights	—	—	1
5.	Evans	—	G	—
6.	Two Knights Defence...	—	T	—
7.	French	—	—	1
8.	Zukertort	G	—	—
9.	Evans	—	G	—
10.	P—Q4	G	—	—
11.	Ponziani	T	—	—
12.	P—Q4	G	—	—
13.	Gambit declined ...	T	—	—
14.	Zukertort	G	—	—
15.	Centre Counter Gambit	—	—	1
16.	Dutch	—	T	—
17.	Vienna	—	—	1
18.	Dutch	—	T	—
19.	Spanish...	—	—	1
20.	.. ..	—	T	—
21.	.. ..	—	G	—
22.	Two Knights Defence...	—	T	—
23.	Centre Gambit... ...	—	G	—

The Attack won 7 times, the Defence 11 times.

Gunsberg was first player 11 times. With the move he won 4, drew 1, and lost 6.

Tschigorin had the move in 12 games. Of that number he won 3, drew 4, and lost 5.

Of 4 Ruy Lopez played (2 by each player), the second player won 3, and 1 was drawn. In two of these White played 4 P—Q4 without obtaining a satisfactory game. In the other two Black defended with 3 P—QR3, and White continued with 4 B—R4, Kt—B3, 5 P—Q3, P—Q3, &c., Black playing P—KKt3, B—Kt2, and Castles KR.

White in each case failed in sustaining an attack against the King's side.

There were six irregular openings. Four games were won by Gunsberg as first player, namely, two Zukertort and two P—Q4 openings; and two P—K3 openings played by Gunsberg were won by Tschigorin. From the play in these games it seems to follow that the defence should post the QB on QKt2, and endeavour to force the centre by P—K4, preceded by P—QB4, and the massing of pieces bearing on Black's K4th square.

Tschigorin won both the Two Knights Defences which he played. We think his success proves that the second player receives a good equivalent in position for the Pawn, but we can hardly say, in spite of the above success, that the defence is superior to the attack. In one of these games, after the usual moves, Gunsberg tried 8 B—Q3, instead of the customary move of 8 B—Q2, but lost much time in his subsequent play, thereby getting a bad game. We think the move feasible.

In the two Ponziani openings Gunsberg did not succeed in getting an even game by defending with 3 Kt—B3, which seems to speak in favour of the defence of 3 P—Q4.

Tschigorin lost two Evans Gambits, he playing 9 QKt—B3, to which Gunsberg replied with 9 B—KKt5 in one game, and Kt—QR4 in another. In both instances the defence proved valid.

The Vienna opening resulted in an inferior position for the first player, as follows:—1 P—K4, P—K4; 2 QKt—B3, KKt—B3; 3 P—B4, P—Q4; 4 BP × P, Kt × P; 5 Q—B3, Kt—B3; 6 B—QKt5, Kt × Kt; 7 KtP × Kt, P—QR3, &c.

In the French defence (Steinitz variation) Gunsberg re-took the QBP with the Knight, instead of with the B, *i.e.* 1 P—K4, P—K3; 2 P—Q4, P—Q4; 3 QKt—B3, KKt—B3; 4 P—K5, KKt—Q2; 5 P—B4, P—QB4; 6 P × P, QKt—B3; 7 B—Q3, Kt × BP, &c.

The Centre Gambit attack failed altogether, as the second player turned the tables completely as follows:—1 P—K4, P—K4; 2 P—Q4, P × P; 3 Q × P, QKt—B3; 4 Q—K3, Kt—B3; 5 QKt—B3, B—Kt5; 6 B—Q2, Castles; 7 Castles, R—Ksq; 8 P—B3, P—Q4, &c.

Finally, in the Gambit declined, the second player got a bad position by allowing White to advance the Gambit Pawn to B5, pin the KKt with the B on Kt5, and also post his QKt on Q5.

THE CLOSE OF THE SEASON.

With the opening of the month of April may be said to close the active season among chess-players. Outdoor amusements commence about this time of the year, and, as a consequence, attendance at the clubs begins to fall off. Among the hundred or more clubs that have been regularly meeting week by week during the last few months in London, there will not probably remain more than twenty or twenty-five in active work; and no doubt the same proportion of holiday recesses would be found to hold good were we to make a general tour of the country. Exceptions would, no doubt, be very few and far between, for in nearly every district we should find a cricket club or some attraction to lure away the young people who are regular attendants at the chess clubs.

In the case of older exponents of the game, chess, even in summer, forms still a suitable recreation to many who may be too tired after the work of the day to take part in out-door sport. It affords an opportunity for quietness and rest of body that no other amusement supplies, and, such being the case, it is no wonder that its practice is carried on by them more or less throughout the year.

At the present time there is no lack of material available for the ordinary student of chess, even though his club may be closed, and all his ordinary opponents scattered abroad in search of health and fresh air. There are so many chess columns running in the newspapers of the country that it would be almost impossible to find a corner where literature on the game was not easily obtainable; and it would be a great surprise to many who now regard the chess season as ending with the last days of March, to discover how eagerly these chess columns are perused in the quiet season, even by players who, on other occasions, hardly display any interest in them, because over the board practice is so ready to their hand.

There are, however, other indications to point to a season of activity in the chess world this year during the summer recess for clubs. In England we are looking forward to an International Chess Tournament at Manchester, when, with liberal prizes and the assurance of a hearty welcome, a large number of visitors are sure to be attracted. This will probably be the principal chess event of the next few months, although master contests are spoken of also in other parts of the world. Then we are promised a gathering at Cambridge, under the auspices of the Counties Chess Association, which is to be revived.

Looking back over the last few months we find much to occasion gratification to the chess-player. County associations have been started in various parts of the country, and have worked most successfully in advancing the knowledge of the game, while, as regards new clubs, it may fairly be said that the space at our disposal would not be sufficient to give even a summary of them. There is hardly a district in the kingdom that does not supply marked evidence of increased popularity for the royal game of chess and a general desire to make its practice more universal.

R. L. O'Beirne.—Berger's book on End-games is the best. In the position you sent we should not like to say for certain that White must win, but it seems so to us. Such endings are extremely difficult. White will of course play his King on a white square, and try and push his Pawns, *i.e.* 1 K—Q3, K—K3; 2 P—B4, B—Qsq; 3 K—B4, B—R5; 4 P—Q5, K—K4; 5 P—B6, B—Qsq; 6 K—B5, B—K2; 7 K—Kt 6, &c.; but there are many ways in which Black might get a chance of stopping the advance.

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CONTENTS.

BINARY STARS OF SHORT PERIOD.

By J. E. Gore, F.R.A.S., M.R.I.A.

The Binary, or revolving double stars, are among the most interesting objects in the heavens. The number now known probably amounts to nearly 1,000. In most of these, however, the motion is very slow, and in only about 60 cases has the relative change of position since their discovery been sufficient to enable an orbit to be computed. In most cases the plane of the real orbit, or ellipse, described by the companion round the principal star, is inclined to the line of sight, and is therefore foreshortened into a more elongated ellipse. Indeed, there is only one case in which we see the *real* orbit of a binary star, viz. in the star μ Draconis, the orbit plane of which, according to Berberich, is at right angles to the line of sight. But the computed period — 648 years — is very long; and the orbit, therefore, of somewhat doubtful accuracy.

The relation of the *apparent* ellipse, which we see, to the *real* ellipse, will be understood by the following illustration. Suppose a cylinder, or rod, of an elliptical, not circular section, to be cut across obliquely to its axis. Then this oblique section will represent the *real* orbit of a binary star, and the section at right angles to the axis the *apparent* orbit. The angle between these two sections will represent the inclination of the real orbit to the plane of projection or background of the sky. In the apparent orbit the primary star, which is supposed to be situated in one of the foci of the *real* ellipse, does not lie in the focus of the apparent ellipse; and from its position in this latter ellipse we can deduce mathematically the particular angle at which the oblique section must be made, to agree with the observed place of the primary star; and other details respecting the *real* ellipse.

The periods of revolution of the computed orbits vary in length from $11\frac{1}{2}$ to 1625 years. Of the 60 orbits which have been computed, there are about twenty-one with periods under 100 years, and these form the subject of the present paper. The orbits of many of these have been well determined, and some account of the most remarkable, with diagrams of the orbits, may prove of interest to the general reader.

1. δ *Equlei.*—This has the shortest period of any known binary star.* Over three complete revolutions have been described by the companion star round the primary since its discovery in 1852. The period found by the Russian computer Wrublewsky—11·478 years—is probably not far from the truth, but, as his orbit does not represent the measures very satisfactorily, I have not drawn the apparent orbit. It is, however, a very elongated ellipse, owing to the high inclination of the real orbit. Burnham found only "a slight elongation" in the star with the great 36-inch refractor of the Lick Observatory in July 1889. The distance between the components does not at any time exceed half a second of arc, so that it is beyond the reach of all but the largest telescopes.

2. ζ *Sagittarii.*—This bright southern star is also a close

* That is, of any binary which has been seen with a telescope as double. Mr. Gore necessarily leaves out of account in this paper such binary systems as those of ζ *Ursæ Majoris* and *Algol*, the existence of which has only been proved by the indirect evidence of the spectroscope and photometer. But our knowledge with respect to the orbits of some of these binary systems of very short period is rapidly increasing, and continued observations will probably give us data from which all the elements of their orbits may be determined, even though we may never be able to see them as double with the telescope. In view of the evidence we already possess, one may assert with confidence that masses of matter, large enough to be seen as stars, revolve about one another in periods ranging from less than eight hours upwards.—A. C. Ranyard.

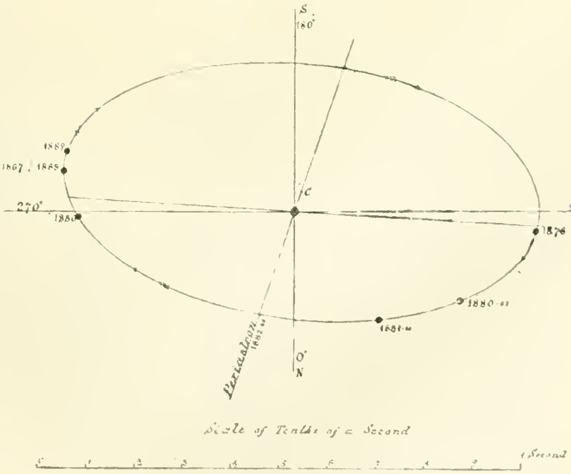


Fig. 1.—Apparent Orbit of ζ Sagittarii.

binary. An orbit computed by the present writer in 1886 makes the period 18·69 years, but recent measures seem to show that the true period is somewhat longer —perhaps about twenty years. Fig. 1 represents the apparent orbit, and shows the position of the companion at different times from 1878 to 1889.

3. 42 *Comæ Berenices.*—The period of this star has been accurately computed, and is about $25\frac{3}{4}$ years. The orbit is remarkable from the fact that its plane passes through, or nearly through, the earth. The orbit is therefore projected into a straight line, as shown in the diagram, Fig. 2. I have also drawn the *real* orbit, as it would appear could we view it from a point at right angles to its plane. I find that the plane of the real orbit is at right angles to the general plane of the Milky Way.

4. β *Delphini.*—The close duplicity of this star was discovered by Burnham in 1873. The period is short, but still somewhat doubtful. Celoria finds 16·955 years, Doubiago 26·07, and the present writer 30·91 years. Celoria's orbit is perhaps the best.

5. ζ *Herculis.*—Three complete revolutions of this remarkable pair have been performed since its discovery by Sir William Herschel in 1782. Several orbits have been computed, but Dr. Doberck's, with a period of 34·411

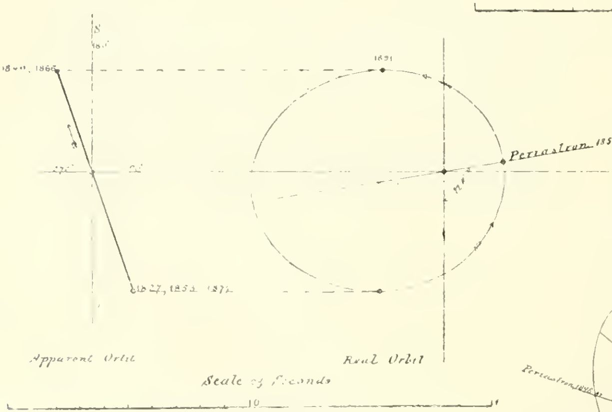


Fig. 2.—42 Comæ Berenices.

years, is perhaps the best. From his elements I have drawn the apparent ellipse represented in Fig. 3. The companion is now near its maximum distance ($1\frac{1}{2}$ seconds) from the primary star, and is within the reach of telescopes of moderate size. The companion is, however, rather faint, being only $6\frac{1}{2}$ magnitude, while the principal star is of the 3rd magnitude. When at their nearest some observers have spoken of " an occultation " of one star by the other; but the diagram will show clearly that no *real* occultation ever takes place, the components never approaching within half a second of arc. An occultation of one component of a binary star by the other cannot take place except—as in the case of 42 Comæ—the plane of the orbit passes through the earth.

6. η *Coronæ Borealis.*—Some forty years ago it seemed uncertain whether the period of this interesting binary

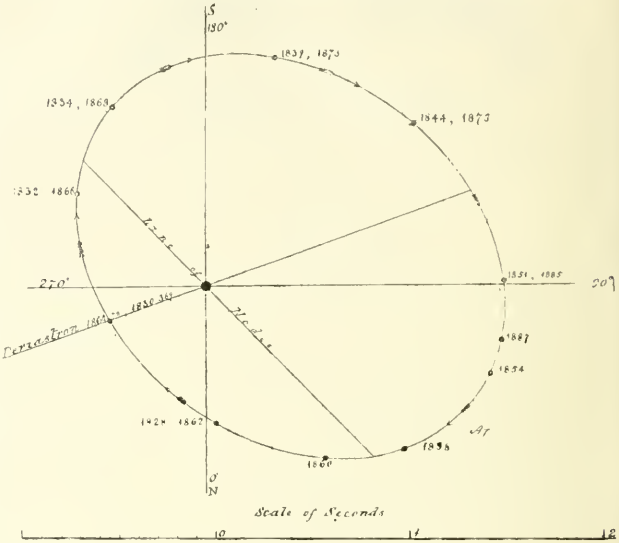


Fig. 3.—Apparent Orbit of ζ Herculis.

star was 43 or 66 years. But now that a complete revolution has been described, the question has been decided in favour of the shorter period. About a dozen orbits have been computed, and of these those by Dr. Doberck and Dr. Dunér, giving a period of about $41\frac{1}{2}$ years seem to be the best. The components are of nearly equal magnitude (6 and $6\frac{1}{2}$), but at their present distance

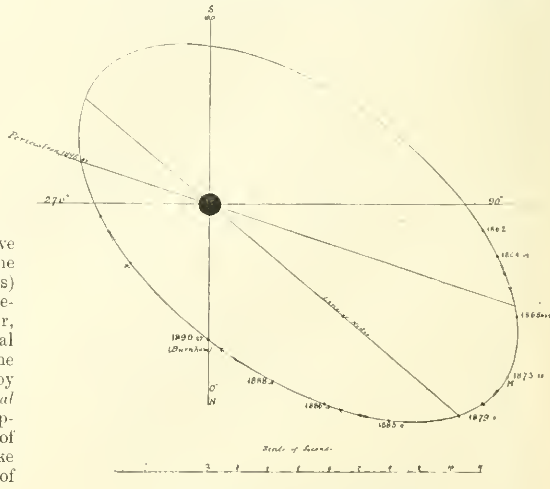


Fig. 4.—Sirius. Apparent Orbit.

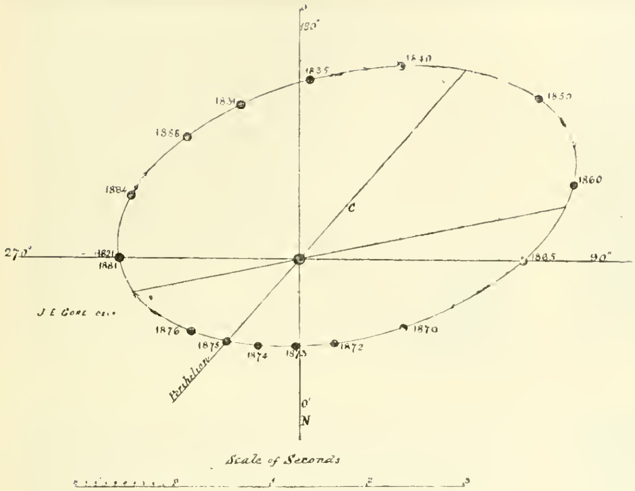


Fig. 5.—Apparent Orbit of ξ Ursæ Majoris

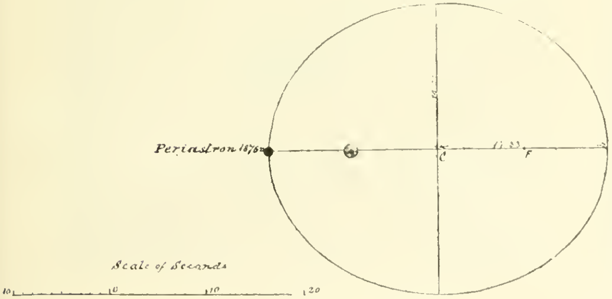


Fig. 7.—A Centauri. Real Orbit.

(about $\frac{3}{4}$ second) the star is not within the reach of small telescopes.

7. *Struve* 2173.—In this pair a complete revolution has been described since its discovery by Struve in 1829. The components are nearly equal, about 6th magnitude; but the present distance is less than one second of arc. Dunér s orbit, with a period of about $45\frac{1}{2}$ years, seems to be a good one, as it represents recent measures satisfactorily. The *real* orbit is nearly circular, but owing to its high inclination (nearly 81°) the *apparent* orbit is a very elongated ellipse.

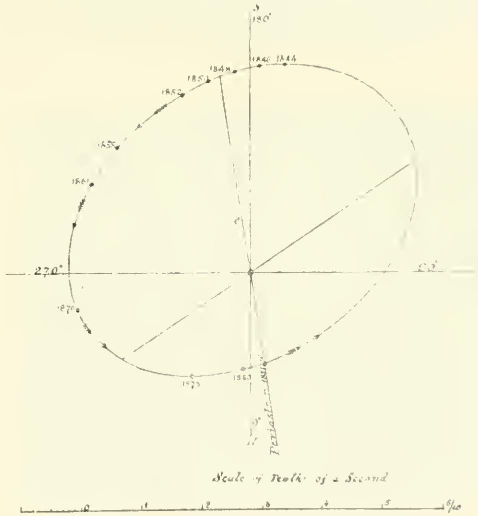


Fig. 6.—Apparent Orbit of O. Struve 234.

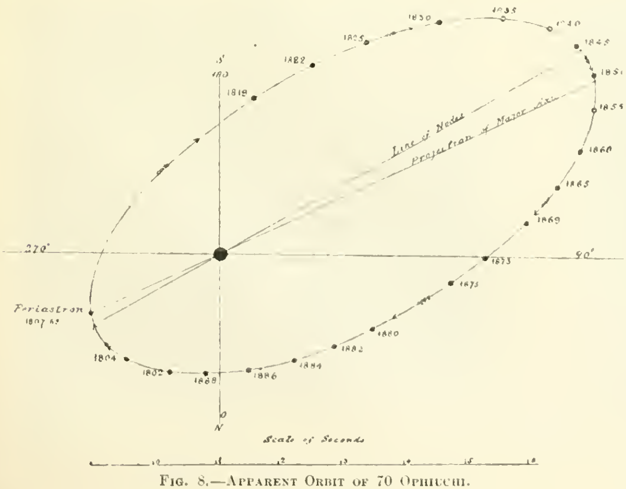


Fig. 8.—Apparent Orbit of 70 Ophiuchi.

8. *Sirius.*—The faint companion to this brilliant star was discovered by Alvan Clark in 1862. Some irregularities in the proper motion of Sirius led Bessel, in 1844, to suggest the existence of a disturbing body, and Peters, in 1851, calculated an hypothetical orbit for the supposed companion. He found a period of about fifty years, with an ellipse of large eccentricity. An investigation was also made by Safford in 1861, and when Alvan Clark discovered the now well-known companion its position was found to agree fairly well with that of Safford's hypothetical body. The companion, which is of about the tenth magnitude, has been regularly observed since, and several orbits have been computed giving periods of about fifty years. Recent measures, however, show, I think, that this period is somewhat too small. My period of 58·47 years (computed in 1889) represents all the measures fairly well. Observing with the 36-inch refractor of the Lick Observatory Mr. Burnham says:—
"The companion to Sirius is a very easy

object, under proper conditions, and is not likely to ever get beyond the reach of the large refractor."

Assuming a parallax of 0·40″ (which is about the average of recent measures) my elements give the sum of the masses of Sirius and its companion equal to 2·886 times the sun's mass, with a mean distance between them of 21·45 times the sun's distance from the earth. I find that the plane of the orbit lies at right angles to the general plane of the Milky Way. The diagram, Fig. 4, shows the *apparent* orbit as found by me. The letter *m* marks the point of minimum distance (and M that of maximum distance). This diagram shows clearly that the minimum distance between the components of a binary star does not always occur at the periastron, as some have supposed. C is the centre of the *apparent* ellipse.

9. γ *Coronæ Australis.*—For this remarkable southern binary star several orbits have been computed, with periods ranging from 55 years to nearly 101, but none altogether satisfactory. An orbit by the present writer gives 81·78 years, and one recently computed by Mr. Powell 93·338 years.

10. ζ *Cancri.*—A well-known triple star, the close pair revolving in a period of about sixty years. Nearly two revolutions have now been completed since its discovery

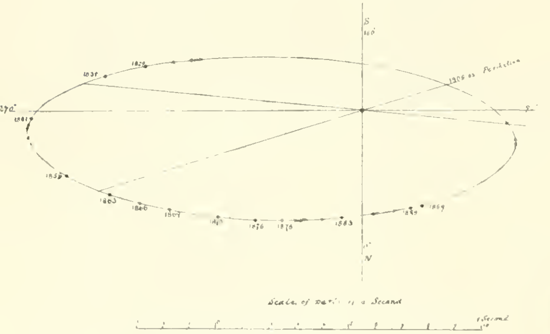


Fig. 9.—Apparent Orbit of Struve 228.

by Sir W. Herschel in 1781. All three stars form probably a connected system, but the motion of the third star round the binary pair is very slow and irregular. Prof. Seeliger has recently investigated the motion of this interesting system, and has come to the conclusion that to make the observations agree with theory it is necessary to assume that the third star is in reality a very close double, the components of which revolve round their centre of gravity in about 17·6 years, and both round the common centre of gravity of the components of the close pair. The supposed duplicity of the third star has not, however, yet been detected with the telescope. Burnham, in 1889, using a power of 1,500 failed to see any other component.

11. ξ *Ursæ Majoris.*—This very interesting binary was the first pair for which an orbit was computed—by Savary in 1830. More than a complete revolution has now been performed since its discovery by Sir W. Herschel in 1780. The period has, therefore, been well determined, and seems to be about sixty years. Fig. 5 represents the apparent ellipse, which I have drawn from Dr. Dunér's orbit. From this it will be seen that although the components are not at present near their maximum distance apart, they are yet within the range of small telescopes, the distance being about $1\frac{3}{4}$ seconds, and the magnitudes of the components not very unequal, about four and five.

12. *O. Struve*, 234.—This is a very close double star for which I computed an orbit in 1886, and found a period of 63·45 years. Owing to the discordancy of the measures, however, this orbit will probably require revision when further measures are available. Fig. 6 represents the apparent orbit I found, and shows the position of the companion from 1841 to 1880. It will be seen from the diagram that the maximum distance between the components is less than half a second of arc, so that the pair is beyond the reach of all but the largest telescopes.

13. α *Centauri.*—This bright southern star, the nearest of all the fixed stars to the earth, is also a remarkable binary. The magnitudes of the components are, according to Gould, 1 and $3\frac{1}{2}$, but as a single star it is brighter than an average star of the 1st magnitude, and about equal in brightness to Arcturus. Although it has been carefully measured for many years the period is still somewhat uncertain. While Downing and Elkin make it 76 or 77 years, Powell maintains that a longer period of about 87 years is more probable. Fig. 7 represents the *real* ellipse as drawn from Downing's correction of Elkin's orbit. Assuming a period of 77 years, and a parallax of 0·75″, I find the sum of the masses of the components 2·14 times the mass of the sun, and the mean distance between them 23·333 times the sun's distance from the earth, or somewhat greater than the distance between the sun and Uranus.

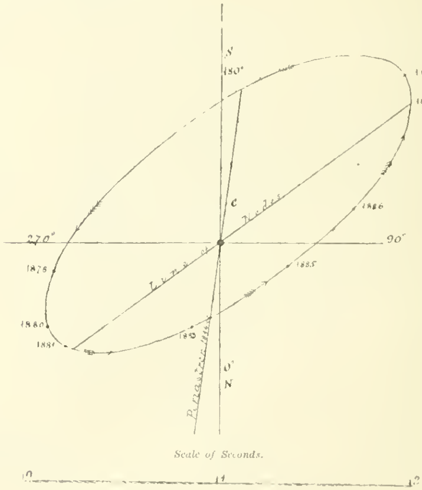


Fig. 10.—Apparent Orbit of ξ Scorpii.

14. 70 *Ophiuchi.*—A splendid double star; magnitudes about 4 and 6. More than a complete revolution has now been described by the companion since its discovery, by Sir W. Herschel, in 1779. Numerous orbits have been computed, with periods ranging from $73\frac{3}{4}$ to $94\frac{1}{3}$ years, but none altogether satisfactory. I have recently computed an orbit, and find a period of 87·84 years. This orbit represents all the measures satisfactorily, and cannot, I think, be far from the truth. The diagram, Fig. 8, represents the apparent orbit I find, and shows the position of the companion in various years, from 1802 to 1888. The distance between the components is at present slightly increasing as the companion approaches the periastron; after which it will diminish for some years, but

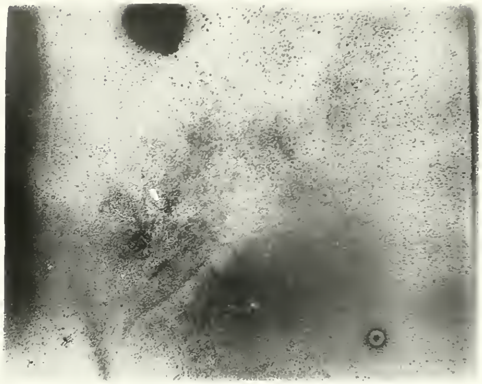
From Photographs taken at the Lick Observatory by Prof. E. E. BARNARD.

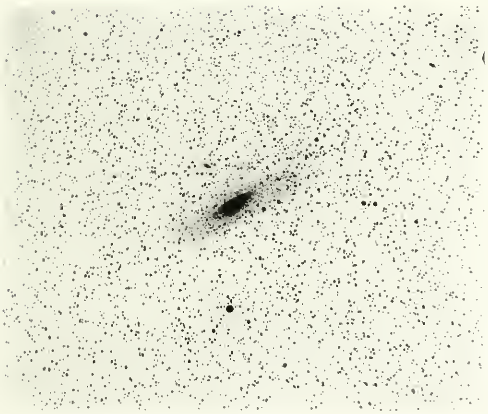
W N S E

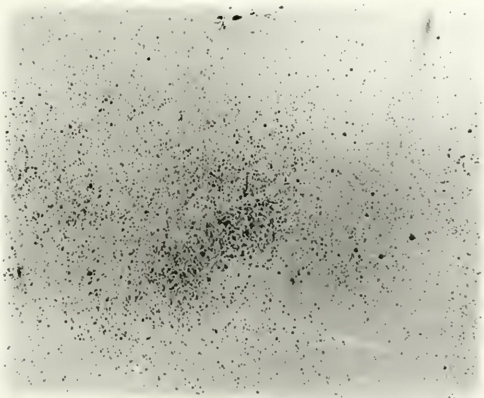
1. Region round the Great Nebula of Andromeda.
Scale—1 inch = 5° 18′.

N E W S

2. Region of Milky Way south of the Trifid Nebula.
The black patch at the top is the over-exposed image of Jupiter. Scale—1 inch = 4° 36′.







W N—S E

3. Milky Way in Sagittarius
Photograph taken 25th July, 1889. Region round 21 Messier 18h. 10m. δ = −18° 28′ Scale—1 inch = 1° 48′.

S E W N

4. Milky Way in Aquila
Photograph taken 2nd Aug., 1889. Region round 11 Messier 18h. 42m. δ = −6° 27′ Scale—1 inch = 2° 30′.

Direct Photo Eng. Co. Limit...

will never be less than $1\frac{1}{2}$ seconds, so that this fine pair will always remain within the range of moderate sized telescopes. My elements, combined with Krüger's parallax of 0·162″, give the sum of the masses = 2·777 times the mass of the sun, and the mean distance between the components 27·777 times the sun's distance from the earth. I find that the plane of the orbit is at right angles to the plane of the Milky Way.

15. *Struve* 228.—I have recently computed an orbit for this pair which represents all the measures from 1829 to 1889, fairly well for so close a star. Fig. 9 represents the *apparent* ellipse I have found. According to this orbit the distance between the components, which is at present about 0·4″, will gradually increase during the next few years up to 0·55″, then diminish again as the companion approaches the periastron. The minimum distance will not be reached till the position angle is nearly 180° (after the periastron passage), when the components will probably be separated by less than 0·2″.

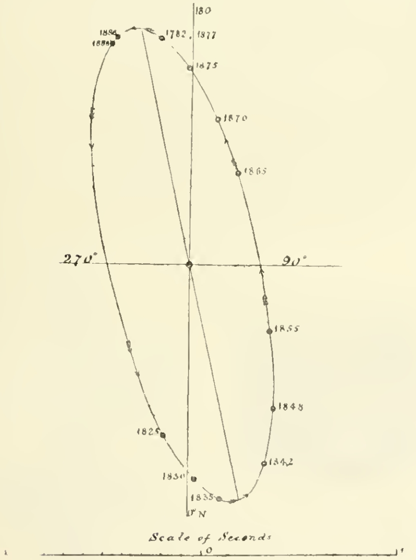


Fig. 11.—Apparent Orbit of 85 Pegasi.

16. γ *Coronæ Borealis.*—For this close and difficult double star Dr. Doberck finds a period of $95\frac{1}{2}$ years. As in the case of 42 Comæ, the plane of the orbit nearly passes through the earth, and the apparent orbit is nearly a straight line. For the past ten or eleven years this star has been "single," even with the largest telescopes. I find that the plane of the orbit is at right angles to the plane of the Milky Way. An orbit has recently been computed by Celoria with a period of 85·276 years.

17. ξ *Scorpii.* A remarkable triple star; magnitudes about $1\frac{1}{2}$, 5, and $7\frac{1}{2}$. The companion of the close pair has described a complete revolution since its discovery by Sir W. Herschel in 1780. Dr. Doberck finds a period of 95·9 years. The real orbit is nearly circular, but owing to its high inclination—about 70°—the *apparent* orbit is a very elongated ellipse, as shown in Fig. 10. All three stars have a common proper motion, and probably form one system, but the motion of the third star is very slow, and its period of revolution must be several hundred years.

18. 85 *Pegasi.*—A well-known wide double star; magnitudes about 6 and 9, and present distance about 22″. In 1878 Burnham discovered the brighter star to be a close and difficult double, and since that year the companion, which is about the 11th magnitude, has described no less than 220° of its apparent orbit. Mr. Schaeberle, of the Lick Observatory, has recently computed an orbit, and finds a period of 22·3 years, with a high inclination, which makes the apparent orbit, shown in Fig. 11, a rather elongated ellipse. Assuming a parallax of 0·054″ found by Brünnow, I find the mass of the system 11·297 times the sun's mass, with a mean distance of 17·777 times the sun's distance from the earth, or a little less than the distance of Uranus from the sun. As, however, the assigned parallax is so small, its accuracy is somewhat doubtful. A parallax of 0·054″ would imply a distance of 3,819,722 times the sun's distance from the earth, or about 60 years' journey for light. From the recorded measures of the distant companion I have computed the proper motion of the binary pair, and find it to be 1·221″ in the direction of position angle 141·25°. This proper motion combined with the above parallax would imply a real motion of about 66 miles a second.

HOUSE-FLIES AND BLUEBOTTLES.—VI

By E. A. Butler.

Flies are subject to the persecutions of animal as well as vegetable parasites, some of which attack them externally and some internally. The chief external one is a reddish kind of mite (Fig. 16). These creatures may be found, principally during the summer months, on different parts of the bodies of the flies, especially on the under surface; here, in the neighbourhood of the attachments of the legs, and at the junctions of the body segments, there are plenty of places—the joints of the armour, as it were—where the skin is thin enough for the mites to pierce with their snouts. They show a good deal of enterprise in endeavouring to secure the best places—no easy matter when there are a good number of them—and when one has plunged its proboscis into the flesh, it adheres most tenaciously, and its body may be lifted up and pushed from side to side without causing it to relax its hold. The flies, though so particular in removing from their persons the slightest trace of inanimate foreign matter, by sweeping and scraping themselves with their legs, yet submit patiently to the presence of their living burdens, even when they get into places whence they could, one would imagine, easily be removed. For example, a *Musca domestica* that has just at the moment of writing alighted on the window pane, flew about unconcernedly with a large mite clinging to its face in such a way as one might suppose would have seriously interfered with the use of both eyes and antennæ. It did not seem,

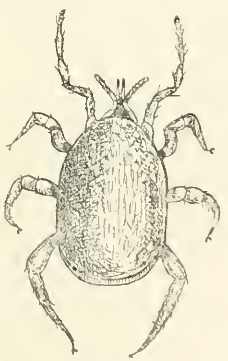


Fig. 16.—Mite Parasite on Fly. Taken from body of *Pollenia rudis*

however, in the slightest degree incommoded. Another external parasite sometimes, but not so commonly, found, is an animal belonging to a group closely allied to the mites, viz. the book-scorpions or Chelifers. It is a little reddish creature with a pair of great pincers in front like a scorpion, but differing in that the body does not taper away into a tail, but ends abruptly. Amongst the internal parasites are various kinds of small hymenopterous insects, allied to the ichneumon flies; and an instance is recorded of an exceedingly fine and hair-like nematoid worm, of the enormous length of three inches, having been taken from the abdomen of a house-fly. M. Fourment, who records the fact, states that notwithstanding that the parasite had caused a considerable enlargement of the body of its host, the latter did not seem in any way inconvenienced in its flight.

We have now enumerated eight species of *Muscidæ* which are more or less intimately associated with man, and which, either by reason of some peculiarity in their economy, or simply in consequence of their numerical abundance, often become a source of trouble and annoyance in the premises we occupy, damaging our food or other property, attacking our persons, or worrying and harassing our nervous susceptibilities. Some interesting questions arise in connection with this undesirable intimacy of relation, but many more observations will be needed before any very satisfactory answers can be given to them. It is not easy to understand, for instance, why these particular species of flies, rather than any others, have elected to attach themselves to man, and to follow his fortunes, as some of them have done, all over the world. It is not that they are so different from other flies that one would necessarily expect them to behave in an exceptional way; neither in structure nor even in habits, except in this one particular, is there anything which will broadly distinguish them from allied species which do not trouble us. There is absolutely nothing that would enable a person ignorant of the species to separate, in a given assortment of flies, those that are household pests from those that are not. We get one from one group, another from another, and so on, but they do not form a compact and isolated company. Their association with man, it is true, is not so complete as that of several other insects, such as the cockroach, the clothes moth, and the bed-bug, which spend their whole lives under the shelter of our houses, and propagate themselves generation after generation without ever troubling themselves about the outside world. As already mentioned, it is only in the last stage of their life that, as a rule, we are annoyed by these flies; but perhaps this limitation may be regarded as making the association all the more remarkable. That as the perfect stage is reached in each succeeding generation, the instinct to betake itself to the abodes of men should regularly recur to an insect born and bred in the open air, is, it would seem, more remarkable than that the association should be a continuous and permanent one. As the nature of the food on which they are reared necessitates, as a rule, that they should pass through their earlier stages exposed, it is rather curious that the perfect insects should not confine themselves to similar localities, but should also enter our dwellings, and often in such surprising numbers.

Nor is it, again, that they are so much more abundant than all other species, and that, therefore, mere excess of numbers causes them to be the species represented indoors; that, in other words, we simply get the overflow from outside. Of course they are abundant—this is implied in their being pests—but there are other species equally so, of which it is the rarest occurrence to find a specimen in the house. Take, for example, the case of *Sarcophaga carnaria*, the flesh fly, which has been several times referred to already. This is an insect of most extraordinary fecundity; it is said that as many as 20,000 eggs have been found in the ovaries of a single female, and, in consequence, it is an extremely common fly; but though its habits are similar to those of the bluebottle, and it swarms round human dwellings, it is very seldom seen indoors. The facts of its distribution seem to show that it is far less dependent on man, and far more inclined to ignore his movements, than our household pests. It is an extraordinarily hardy insect, and shows wonderful powers of adaptation to circumstances. Even in the matter of food, which is often such a critical point with a larval insect, it can stand some degree of variation, feeding not merely on meat, either fresh or putrid, and wounds and ulcers on men and other animals, but even on decaying vegetable matters and dung as well. Even if half-starved, it will still undergo its metamorphoses, though, of course, the perfect insects will be dwarfed. Like several others, it can even withstand the action of the digestive fluids of the stomach and intestine of living vertebrate animals. Bernard introduced it artificially into the stomach of a dog, but it passed along the intestine and was voided in the usual way alive; Portchinski's similar experiment with a frog had the same result. In the case of a little song-bird, however, the larva was dead when voided, but still undigested. That so common and so hardy a European fly should be one of the most likely to follow man's lead and migrate with him to other parts of the world would be only what was to have been expected, and yet, though the five flies mentioned at the commencement of these papers, together with *Cyrtoneura stabulans*, are as common in the United States as in Europe, though not indigenous there, *S. carnaria* has, according to Osten-Sacken, not yet been introduced into America, so that four centuries of European communication with the new world have not sufficed to import this abundant but independent species.

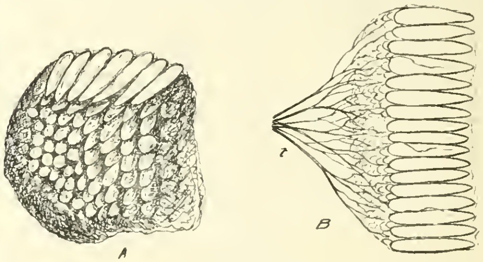


Fig. 17.

(A) Portion of Left Ovary of Bluebottle, containing about 80 Eggs.

(B) Side View of Portion of Right Ovary, showing Distribution of Tracheæ, or Air-Tubes (t), to the Organ.

The curious observations of Portchinski have an important bearing on the subject, though perhaps they will hardly justify the conclusions he has drawn from them. He finds that carrion-feeding flies are, as a group, enormously prolific, while dung-feeding species are much less so; for example, *Calliphora*, a carrion-feeder, lays from 300 to 600 eggs, while *Musca domestica*, a dung-feeder, lays only about 120. (Fig. 17 shows the method of distribution of the eggs in the ovaries; they lie side by side in a compact mass.) These differences, he argues,

are connected with the different conditions, as regards the struggle for existence, under which the contrasted species live. There are, according to him, comparatively few species of carrion-feeding flies in our regions, so that they have it all to themselves, with little competition, the numerous beetles that have similar habits being said to feed quite as much on the fly larvæ themselves as on the carrion. Their action must, from the nature of the case, be rapid, and the supply of food he regards as plentiful. All these conditions favour multiplication, and have contributed towards producing the extraordinary fecundity for which the insects are noted. There is one other point which lessens the competition, viz. that the different species to some extent succeed one another during the summer in point of time (*i.e.* in the larval form), instead of being contemporaneous. This was proved in the following way: he laid out of doors the dead bodies of small vertebrates, such as rats, birds, &c.; the flies soon laid eggs upon them, and these were then collected and the maggots bred to maturity, whereby the relative numerical abundance of the species was ascertained. One of the chief results thus established was that *Cynomyia mortuorum*, an out-door flesh-fly, was abundant in spring, but *Calliphora vomitoria*, a bluebottle, did not begin to appear till about the beginning of June, when the former species had begun to decline. Later on, the proportions were reversed, the bluebottle being in excess, and the flesh-fly scarce. Thus everything favours the fecundity of the carrion-feeders.

But with the dung-feeders the case is different. Here there is much competition, there being large numbers of dung-feeding flies, as well as beetles, which latter do not feed on the former. The supply of food, too, Portchinski regards, curiously enough, as less abundant. These are circumstances which place fecundity at a disadvantage, and hence have sprung the more moderate powers of multiplication possessed by the dung-feeding fles. But here, again, a very curious circumstance has arisen, which gives an extra advantage to the less prolific species. There is a fly which is structurally very like *M. domestica*, differing chiefly in the brighter colour of its abdomen (Fig. 18), which is of some tint of yellowish or brown. Its name is *Musca corvina*, and it frequently hibernates in houses, and may therefore be reckoned amongst the household species. Notwithstanding the close resemblance between these two species in their perfect condition, as well as in that of the full-grown larvæ, there is a most extraordinary difference in the circumstances of their development. While the house-fly lays 120 eggs, *M. corvina* lays only 24, but they are much larger, and hence the larval life is able to be shortened; this is done at the expense of one of the two transformations. *M. domestica*, as before mentioned, passes through three stages in its larval life, while *M. corvina* has only two, the second of the three being, in its case, omitted altogether. This enables it to come to maturity sooner than its relative, and hence gives it an advantage which counterbalances its low degree of fecundity. In some such way as this, Portchinski considers that more prolific flies have been weeded out by less prolific ones from amongst the dung-feeders, so that the majority are now of the less prolific type. But *M. domestica*, with a degree of fecundity which, though low as compared with the carrion-feeders, is yet high for a dung-feeder, is apparently an exception amongst the latter, and herein M. Portchinski finds the explanation of its close association with mankind, the bond of union being, in fact, in this particular species probably closer than in any other, for the house-fly is said to be rarely found far from human dwellings. According to the above theory, the house-fly has sought the protection and additional resources of man's society to aid it in its struggles with less prolific insects, which, by their shorter larval life, would otherwise have hurried it out of existence. Whatever may be thought of these speculations, and it would obviously not be difficult to raise objections to them, still the observations on which they are based have revealed some very curious facts which require to be accounted for in some way or other, and which invest with special interest the history of the relations between insects and man. Farther researches by the same investigator show that the developmental history of an insect may depend very much upon climate, the same kind of fly developing in a different way in northern and in southern latitudes.

Fig. 18.—Distribution of Colour on Abdomen of Musca Corvina. The clear parts are yellow, the shaded parts black.

However exclusive the tastes of their larvæ may be, some at least of these flies seem to be almost omnivorous in their perfect stage, and therefore, possibly, food is one attraction which allures them into our houses; but then again comes the question "Why these alone? Why do not the abundant supplies man's providence stores up become equally enticing to other closely allied forms, whose tastes and needs one would suppose to be similar?" Flies generally manage to find out the room in which the provisions happen to be placed, though the aspect of the apartment has certainly quite as much to do with the numbers that find their way thither as the mere presence of eatables; if the room be bright and sunny, the flies will swarm, while the same provisions in a dull and shady room will be almost ignored. And again, apart from the occasional intrusion of an unwelcome bluebottle making straight for the cold meat, the bringing in of meals does not usually produce any noticeable increase in the number of flies in the room; often many of those that are there seem supremely indifferent to the viands that may be displayed, and continue to amuse themselves by sporting about the windows, mirrors, picture-frames, or gas pendants. We must not forget, however, that what is not food to us may yet be so to them, and they appear to find in these various household objects some sort of nutriment, to judge from the industrious way in which, for example, they will travel over the painted window-frames, dabbing their proboscis down with as much persistence and energy as if they were making a most luxurious feast. What is it they get? Is it the varnish, or the oil with which the paint was mixed, or is it the thin film of miscellaneous matter—dirt we call it—which gradually accumulates on every exposed surface? On any of these suppositions, one would suppose that there would be at least as much to be obtained out of doors as inside, and probably a good deal more.

Such species as hibernate in the house, like *Pollenia rudis*, no doubt come in for the sake of shelter from winter's cold. These gradually accumulate, instead of suddenly coming in a swarm. An instance has been recorded of two other species of the same genus swarming in the same building, to the exclusion of others, for seven successive years; the suggested explanation was that there were certain conditions which facilitated the entrance of the flies, but rendered their exit difficult.

The Editor regrets that want of space has prevented the insertion of any Notices of Books this month.

THE BREAD-FRUIT TREE AND THE NETTLE FAMILY.

By R. Camper Day, B.A.Oxon.

The first description of the bread-fruit was given in 1688 by Dampier. He declared its flavour to be intermediate between those of bread and roast chestnuts. "The inside," he said, "is soft, tender, and white, like the crumb of a penny loaf. There is neither seed nor stone in the inside, but all of a pure substance like bread." About a hundred years later, Captain Cook described the plant more accurately. "The tree that bears the bread-fruit is about the size of a horse-chestnut; its leaves are near a foot and a half long, in shape oblong, resembling in almost every respect those of the fig-tree; its fruit is not unlike the Cantaloupe melon either in size or shape; it is enclosed in a thin skin, and its core is as large as a person's thumb; it is somewhat of the consistency of new bread, and as white as blanched almond; it divides into parts and they roast it before it is eaten; it has little or no taste." Everybody knows how much interest was aroused in this country by Captain Cook's praises of the bread-fruit, and how the *Bounty* was sent out for the purpose of transplanting a number of specimens to the West Indies, where it was supposed (wrongly, as the event proved) that the newly-discovered vegetable would supersede the banana as the staple food of the natives. The transplantation was successful enough, but it was soon found that the bread-fruit could not compete with the banana in rapidity of growth, and in the production of a maximum quantity of food with a minimum of labour. The bread-fruit, however, has undoubtedly better qualities as a food. It has, according to Mr. A. R. Wallace, "a slight and delicate but very characteristic flavour, which, like that of good bread and potatoes, one never gets tired of." In some kinds there are large seeds, which ripen; but in those commonly used for food (and the bread-fruit forms the chief food of the South Sea Islanders) the seeds are aborted, and the whole fruit can be eaten.

The general appearance of the bread-fruit when nearly ripe is well shown in one of the photographs which accompany this article. The larger of the two fruits is about eight inches long. The colour is a light green, changing to yellow at maturity.

Although the size of the fruit and the close resemblance between the edible portion and ordinary bread are the points that have appealed to the popular imagination, the bread-fruit tree is not without other remarkable characteristics, which are not so generally known. In the first place it is a member of the very interesting family to which our nettles belong. At first sight, nothing would seem more dissimilar than the bread-fruit, as shown in the photograph, and our common stinging nettle; not to mention other points of difference, the leaves of the former are large, smooth, and leathery, while those of the latter are small, and densely covered with down and stinging hairs. The chief resemblance is in the flowers. All the nettle tribe have separate male and female flowers; in some cases both are to be found on the same plant; in others, as with our commonest kind of nettle, an individual plant bears male or female flowers exclusively. On the bread-fruit tree the male flowers are clustered in large catkins, roughly resembling the heads of bulrushes; the female flowers are clustered upon small round balls, which afterwards expand and become the bread-fruit. Of the three kinds of nettles in Great Britain, the rarest has several peculiarities which remind one of the bread-fruit. It is monœcious, that is, both male and female flowers are found on the same specimen; and the female flowers are clustered together into little round balls which have earned for the species the distinctive name of "pill-bearing" (*pilulifera*).

The English representatives of the family are very few. Besides the three kinds of stinging nettles above mentioned, there are the common pellitory and the hop, and these exhaust the list, unless we include the elm, which is closely allied. But the tropical species are very numerous. Among these may be reckoned the hemp, which, although cultivated in England, is not a native; the mulberry; the banyan, remarkable for the adventitious roots thrown down from the boughs, by means of which its crown can be indefinitely extended; and the slow-growing caoutchouc plant, so much used for decorative purposes. Perhaps the two members of the family which, for different reasons, have acquired the greatest celebrity are the peepul and the upas. The former is the sacred tree of the Buddhists and Hindoos. The venerable specimen shown in our second photograph is the Sacred Bo Tree of Anhuradhpur, Ceylon. It is probably the oldest existing tree of which the date of planting is recorded. Taken as a cutting from the tree in which Buddha himself was supposed to have been cradled, it was planted in the year 288 B.C. It is now in a somewhat decrepit condition, as shown by the props supporting the branches; but no one is allowed to injure it, and only the leaves which fall naturally are distributed to pilgrims. The upas tree of Java, on the other hand, enjoyed for some time a notoriety of a most unenviable kind. About a hundred years ago a traveller from Java published in the *London Magazine* a very exaggerated account of the tree. He declared that the vapour given off by it was so poisonous as to destroy almost all living things within a radius of fifteen miles. Condemned malefactors, he said, were sent to fetch the poison, and not more than two in every twenty returned alive. The upas did not deserve the evil reputation which it acquired in consequence of this description. As a matter of fact, the tree grows in thick forests, and, although it secretes a deadly poison (strychnia), it does no harm to living things near it unless they actually rub against it; and even then it merely causes an irritation of the skin.

But the fact that the upas secretes poison is undoubted, and indeed the secretion of fluid matter, poisonous or otherwise, is characteristic of the whole nettle family. The stinging hairs of the common nettle, and the bitter gum-resin of the hop, as used in brewing, are well known to everybody. Three different kinds of poisonous material are extracted from hemp. They are known as bhang, ganjah, and churras, and all of them are smoked in India in much the same manner as opium. But there is another and more harmless kind of secretion universally characteristic of the nettle family. If you cut off the top of a common nettle a white milk-like liquid immediately begins to exude from the wounded end of the stem. It consists of a watery fluid, with exceedingly small granules suspended in it, which, as in the case of cow's milk, are the cause of its opaque appearance. When the fluid exudes and comes into contact with the air the corpuscles have a tendency to stick together and harden into a gummy substance. In every member of the nettle family this fluid is to be found. The cow-tree, a native of Venezuela, yields from incisions in the trunk a particularly copious white juice, resembling milk in taste, which is used as an article of food; and nearly all the tropical species of nettles yield it in the form of lac, resin, or india-rubber.

The question, then, arises, What is this peculiar liquid, and what useful office does it perform in the economy of


FICUS RELIGIOSA.
THE SACRED BO TREE AT ANURADHAPURA.
MOST PROFOUND VENERATION TO THE
GAUTAMA IS SAID TO HAVE ATTAINED

plant life? It is certainly not the sap. The sap consists of water sucked up by the roots and the products of assimilation drawn from the leaves. The sap is entirely liquid, and contains no solid bodies in suspension. It does not circulate through the plant in tubes; for the substance of a plant is built up of closed cells and vessels. The transference of the sap from cell to cell can only take place by what is called diffusion, that is, by penetrating through the partitions between the cells; and, moreover, it is probable that the greater part of the water which ascends from the roots to the leaves finds its passage not by this slow diffusion but by permeating continuously the substance of the walls which enclose the cells. It is clear, therefore, that the sap cannot convey solid particles, and consequently the juice which exudes from the wounded stem of a nettle cannot be the sap, because, as already stated, it contains minute granules in suspension.

This juice is known to botanists as the Latex. Unlike the sap, it is contained in continuous tubes or veins, which ramify in innumerable quantities throughout the entire substance of the plant. If it were possible by any means to destroy all the other tissues of such a plant as a large *Euphorbia* (for the nettle family is by no means the only family in which these latex tubes are found), then, as Sachs has pointed out, "the entire form of the plant would still be preserved as a mass of very fine threads of various thickness, representing the ramifications of the original latex-cells; just as the injected vascular system of a vertebrate animal after the removal of all other tissue allows the whole organisation of the body to be recognised." From the fact that the latex-cells run in such large numbers through every portion of the tissues it is evident that their contents must play a very important part in the physiology of the plant. The exact nature of that part has not been completely made out, but this much may be said, that it is analogous in some respects to the part played by blood-vessels and veins in animals. In other words, the latex-tubes contain substances of two kinds, those which in combination with the liquids and gases absorbed by the plant are utilised in its growth, and those which are not so utilised but remain in the latex-tubes as excretions or secretions.

It would be incorrect to suppose, however, from the analogy of the blood-vessels in an animal, that there is anything in the nature of a circulation of the latex in the latex-tubes. When an animal is wounded the blood immediately begins to flow, in consequence of the pumping action of the heart. The fact that when a latex-bearing plant is wounded the latex immediately exudes, might seem at first sight to be evidence of a circulation of the latex. If the bore of an extremely fine glass tube be filled with liquid, and the tube be then broken in the middle, there will be no discharge of the liquid from either of the broken ends. Assuming, therefore, that the latex does not circulate we must look for some special reason to explain the fact that it flows so readily from the smallest incision.

The cause we seek is to be found in the phenomenon known as "turgescence," and the manner of its action is explained by a simple experiment given in Sachs' admirable work on the physiology of plants. If we cut a fresh and flourishing leaf-stalk from a rhubarb plant, we have a fairly rigid and elastic staff which does not bend by its own weight when we hold it horizontally by one end. If a strip of the skin be peeled neatly off from one end to the other, and we then try to fit the piece of skin back into into its place, we find that it is too short. We may infer, therefore, that before it was peeled off it was in a state of tension, and that as soon as it was removed it contracted. If instead of removing merely a strip we peel off all the skin, we find not only that the skin becomes shorter, but that the remainder of the stem becomes considerably longer. If the stem was originally a foot long, it may now be as much as thirteen inches. The skin is limp and flexible, and so also, in a less degree, is the soft interior of the stem; the soft interior has still a certain amount of stiffness, for the substance of the cell-walls and vessels contribute in some measure to the rigidity of the stalk, but neither the skin nor the stripped interior can be held horizontally without bending. In fact, the stiffness of the uninjured stalk is mainly due to the mutual tension and pressure between the skin and the mass of soft tissue enclosed in it. It is evident, therefore, that the substance of a plant is under strong hydrostatic pressure, to which much of its rigidity and elasticity is attributable. A single cell is compared by Sachs to "a thin-walled caoutchouc balloon which, when empty, is a limp, wrinkled sac, but which may be converted into a firm, elastic sphere by being strongly inflated with air." "If we suppose," he says, "some hundreds of thousands of small caoutchouc balloons thus inflated with air, and all contained together in an extensible caoutchouc vesicle, the latter with its contents would form a rigid bar, like the stem of a plant. If we suppose the small caoutchouc balloons not inflated with air but filled tense with water, the same effect results; and it is somewhat in this manner that we have to imagine the rigidity of a stem produced by the turgescence of the cells." From this it is sufficiently clear that the expulsion of the latex from a cut surface is caused by the high pressure in the substance of the plant, and we have thus a complete solution of one of the many problems suggested by the latex-tubes.

Letters.

Reprinted from the "Times" of 5th July 1890.

The Gateway of Lincoln's Inn.—The following letter has been forwarded to the Benchers of Lincoln's Inn, on behalf of the Society of Antiquaries, by the president of the society: "Society of Antiquaries of London, Burlington House, Piccadilly, W., July 2, 1890. To the Benchers of the Honourable Society of Lincoln's Inn. My Lords and Gentlemen, In December, 1885, at a meeting of the Society of Antiquaries of London, I was authorised by a unanimous vote of the society to sign a memorial praying you to countermand the threatened destruction of the gatehouse court of Lincoln's Inn with the chapel, hall, and the interesting chambers known as No. 24, where once lived Secretary Thurlow. Since that time the buildings have been preserved, but it now appears that they are again in danger of destruction. From an independent survey of competent architects, I have reason to believe that the dilapidated condition of the buildings has been much exaggerated, and that by a comparatively small expenditure on judicious repairs the buildings may be placed in such a condition that they will last for many generations to come. I therefore again venture to address you in the name of this society, and to intercede on their behalf for the preservation of these interesting memorials of a past age, the destruction of which would be as deeply regretted as it is apparently needless. I have the honour to be, my Lords and Gentlemen, your obedient servant, John Evans, President of the Society of Antiquaries of London."

LINCOLN'S INN GATEWAY.

Sir,—As you are going to give us some more "exactly-described" knowledge about this "interesting" ruin, and profess your readiness to give it on both sides, I send a few more remarks on your four manifestoes of July.

In spite of a warning last month which would have made any man pause who is not perfectly reckless, you plunge on to back up your statement that "rebuilding could not for a moment be defended from an investment point of view," by making some financial assertions even more demonstrably wrong than that was, and nothing to the purpose if they were right. By some inferential conjuring that I am not concerned with, you profess to prove that our rebuilding of chambers hitherto has produced "an actual loss of income." The sentence is rather obscure, but if it does not mean people to understand that, it means nothing; and I know that it has made people so understand. Your suggestion that I ought to compare our new rents with what we might have got by turning the Chancery Lane front into shops is a nice specimen of what antiquaries will turn round to say the moment they want a pretext for vilifying those who will not listen to their nonsense. Now for the facts.

I happen to have (not made for this purpose, but when I was objecting to further rebuilding a few years ago, because we should have had to borrow money for it) a return of the results of all our rebuildings of chambers up to that time, showing the cost of every successive block, including all temporary loss of rent and interest, and the cost of all single chambers that we had to buy, which increased the cost of one block in a high proportion. Yet not even in that case is your statement true; and on the average of the very large sum that we have spent, the "profit rental" in that return was close on $3\frac{1}{4}$ per cent. From various causes some chambers, both old and new, are vacant, and, as you have such a passion for old ones, it is strange that you prefer to live in the new ones, and quite out of sight of your beloved Old Square and the abode of Thurloe. "Comment is superfluous," as newspapers say, on such audacious inventions about a plain matter of figures as you have chosen to publish; obviously for mere personal prejudice, and when you might easily have asked beforehand whether such statements would be safely true, as you have asked many other questions, I know.

For the same purpose (for it has nothing upon earth to do with this question) you choose to talk of my "unnecessary additions to Inigo Jones's chapel." I know that you avow your indifference to architecture and churches, except so far as they are food for antiquaries. But other people do not, and there was not a word of objection by anybody to our restoring the chapel as we did, which was all but falling, especially the roof, and had no vestry but a small closet with a candle, and no west wall but a mere party-wall which had been cut to pieces. It had not indeed the honour of harbouring a party of traitors and would-be murderers, like your pet No. 24, but only of having produced more archbishops, bishops, and other eminent dignitaries than any other church in England as its Preachers—far more than the Temple, with which of course we cannot compete in some ways, and have only spent about a seventh, I believe, of what that cost to restore.

After these specimens of your mode of controversy I shall notice no more of your assertions and insinuations, all made with the same object and motive, and only add a few remarks on your own and your professional experts' architectural engineering. I wonder that any man calling himself a lawyer did not see the absurdity of citing to a body of lawyers the opinions of a set of witnesses of that class, against those whom the Bench had consulted with exactly the same object as yours, but who confessed that they could not support it.

Are you and your architects really so ignorant as to suppose that large gas-pipes with corresponding nuts are not as good as smaller rods for tying such walls together? Or to imagine that our Clerk of the Works was such a fool as to think of screwing the leaning-out walls "into the perpendicular," which would have broken them to pieces in five minutes, unless a vast deal of other work was done to prepare for it? I am continually finding deeper depths than I had fathomed before in architectural engineering; and here is another. I suspect the pit is bottomless. They do, however, leave you the monopoly of folly, in mistaking the outside wooden slabs, which only spread the hold of the ties over the wall, for props, as mere pretences of danger.

But they have overshot their mark, and yours, by their elaborate descriptions of the mischief done to the building by "many and careless cuttings" by successive owners, and express their surprise at the building having stood at all. Their "reports" are full of "cracks," in one case "from top to bottom," "splits," "ugly fissures," "bulges," bad modern lead flats, with the timbers under them; parapets which must be rebuilt, and at least one chimney, and an indefinite quantity of "face brickwork," and part of the south tower (which by the way is not a tower at all, but only two fronts without an intervening wall); and they point out that the south wall of the north tower above the ground floor stands on nothing but a single prop; and the removal of the old wall there to make the footway has caused "the most serious rents of all" above; and the windows have been mostly widened to put in the mean sashes and panes which we see, and you admire, and which "are generally poor, or worn out," and "the usual plank lintels" over them, "and other poor building contrivances without proper consideration," which, of course, have shrunk and bent, and caused more cracks above, "due to want of care in the insertion of the windows"; and "a cellar has been dug out much deeper than the foundations, and close to them; and here there is a slight settlement visible in Chancery Lane," though you "have verified the levels, and satisfied yourself that the footings have not sunk an *inch*"; another brilliant specimen of your ideas of an insignificant sinkage. And "other parts of the building require to be taken out and rebuilt," and "the whole *attended* to from the foundations to the chimneys." I do not remark on the architects' omissions, but only on their admissions.

When men of common sense, at all versed in the ways of "experts," find three reports full of such statements as these against the party that employed them, they can thoroughly appreciate those expert attempts to override their own admissions by a mere assertion that "there are no serious difficulties to overcome," and that "the work may be well done by a clerk of the works under the clear instructions of a practical surveyor," which means that an architect is to be turned in to do what he likes.

And all what for? Not even for the pretence that this place can ever be made habitable again according to modern wants, in such a sense that any gentleman will live or practise there; especially now that there are so much better chambers to be had, besides other old ones not quite so bad as these for those who, unlike you, have a taste for using them; or who being there, do not think it worth while to move. At any rate, you and your friends have been kind enough to prove that the place is a mere ugly ruin. I wonder how many of your screamers have

taken the trouble to go and look at it. I know that some of the most furious have not. So now I take leave of you.

Batch Wood, St. Albans. GRIMTHORPE.

P.S.—I just add that this was written and in type before you and your allies gave me the chance of answering you in the *Times* of July 21.

[I am glad to read Lord Grimthorpe's last sentence, for our readers would probably feel that they were having too much of Lincoln's Inn if the discussion were continued.

I will therefore be careful not to write anything that could give Lord Grimthorpe the right of claiming a further hearing on this subject. To carry on the discussion would be useless, from my point of view, for the Benchers have now decided not to pull the gateway down; and Lord Grimthorpe cannot assert that he is silenced, for he has opened the question in the *Times*, and even *Mr. Punch* has joined in recommending his "Dear Noble correspondent to the *Times*" to let Lincoln's Inn Gateway and archæology alone.

I will therefore content myself with saying that, as far as I have data to go upon, the figures do not seem to me to support Lord Grimthorpe's computation as to interest. I have not been able to learn the total sum expended by the Benchers in rebuilding, or the total rentals (old and new), though (encouraged by Lord Grimthorpe's statement that I might have asked) I have made application to the steward of the Inn for the figures; but was, as I expected, courteously told that he was not at liberty to give me such information. This secrecy with regard to the affairs of the Inn is, I think, rightly regarded as indefensible by the members of the Bar, who are aware that in the time of the Commonwealth members of Lincoln's Inn received a life interest in their chambers on paying a fine of twenty-five shillings to the Bench. The amount of the fine soon rose to ten pounds, and then to twenty; in George the First's time it was generally about a hundred pounds, and it is only during the present century that members of the Bar have been reduced to the position of ordinary tenants at an annual rental, without any voice in the expenditure of the large revenue derived from them.

Lord Grimthorpe was good enough to divulge the secret of the Benchers with regard to the cost of building his last block of chambers, and we are able to make an approximate estimate as to the old and new rentals. I see no reason to alter the statement I made in the last number on the subject. As to the cost of making Lord Grimthorpe's addition to Inigo Jones's chapel, I estimate the loss of revenue to the Inn to be about £2,000 a year; that is the interest on £10,000 expended in building, and £1,500 a year the rental of chambers pulled down to enable Lord Grimthorpe to alter the proportions of Inigo Jones's chapel and improve a vestry with which, according to his own showing, "archbishops, bishops, and other eminent dignitaries" had been content. The chapel is but little used now-a-days, and there is certainly no general wish amongst the Bar of Lincoln's Inn to compete with the Sunday shows at the Temple.

Lord Grimthorpe's great energy finds vent in building; he enjoys the construction and evidently also the destruction it involves, as some men enjoy sport. He is willing to pay highly for the right to exercise his hobby at St. Alban's Cathedral, and Lincoln's Inn was a sort of free warren for him. He is naturally annoyed, as sportsmen always are when their sporting rights and liberties are interfered with. I regret that I should have felt that it was necessary in the public interest to interfere with what contributes to his enjoyment; for, putting aside some antiquarian and other minor matters, there are many more important questions on which I heartily agree with him. I sincerely respect him for his attack on the system of paying commissions to agents, and for his out-spoken opposition to the endowment of research, and the awarding of medals by members of scientific societies to their contemporaries and co-workers.—A. C. RANYARD.]

Prof. H. M. PAUL, of the U.S. Naval Observatory, has discovered a remarkable new variable star (S Antliæ), which appears to be of the Algol type, with a period of 7h. 46m. 48s., the shortest yet discovered. It varies about six-tenths of a magnitude from 6·6 mag. to 7·2 mag. And according to Mr. Chandler it remains at maximum brightness about 4h. 30m., the decrease and increase each occupying 1h. 40m. In other words, the eclipsing star only occupies about 35 minutes in passing from extreme elongation to the position where it commences to cut down the light of its primary—a time which seems to indicate that the dark body is within a radius of the bright star and far within Roche's limit (2¼ radius), within which a satellite cannot exist, revolving round a homogeneous primary. Unfortunately this star is situated too far south for English observers at R.A. 9h. 26m. 50s. S. Dec. 28° 4′ 43″.—A. C. R.

TEETH AND THEIR VARIATIONS.

By R. LYDEKKER, B.A.Cantab.

(*Continued from page* 178.)

OUR last illustration of the gradual increase in the complexity of the structure of the grinding teeth in the Ungulate order, as we proceed from the old extinct generalised types (and some allied ones which still survive) to the specialised forms characteristic of the world of to-day, will be derived from the peculiar group of Elephants. At the present time, it need scarcely be mentioned, there are but two species of Elephant, both nearly related, but one being confined to the African Continent and the other inhabiting India and some of the adjacent regions. In the latter Tertiary period of the earth's history Elephants were, however, much more numerous, and were spread over the greater part of the surface of the globe, having been obtained from Europe and Asia, as far north as Siberia, North and South America, and North Africa. Many of these extinct Elephants, and, indeed, all of the earlier ones, differed very remarkably from the living species in the much simpler structure of their teeth; these species being known as Mastodons, a term which has now become almost a popular one.

FIG. 12.—AN ANTERIOR CHEEK-TOOTH OF A MASTODON.

In common with true Elephants, Mastodons differ from other Mammals, in that, instead of having all their cheek-teeth in use at the same time, the hinder ones gradually come up in an arc of a circle behind the tooth in use at any one particular period, which is gradually worn away and shed. Further, the teeth gradually increase in complexity from before backwards, the most anterior ones in some cases not having more than two ridges (Fig. 12), while the hinder ones are much more complex (Fig. 11). It results from this peculiar mode of succession that there are never more than portions of two, or at most of three, teeth on either side of each jaw in use at any one time. Fig. 12 shows that the simple cheek-teeth of a Mastodon are really constructed on the same general plan as those of a Pig (Fig. 1), the outer cones having more or less completely united with the inner ones to form two transverse ridges. In some of the earlier teeth of the Mastodon there may be only two such ridges (Fig. 12), but in the later

ones the number of ridges is generally either three or four (Fig. 13), with additional imperfect ridges at the two extremities. In such a tooth (Fig. 13) it will be seen that the transverse ridges are low and roof-like; the valleys separating one ridge from another being broad and comparatively shallow, without any of the substance known as cement at their bases. When the enamel on the summit of such ridges is worn through by the abrasion of the teeth of the upper jaw against those of the lower, oval or trefoil-shaped islands of the underlying dentine are revealed, as in Fig. 14. The latter figure exhibits the last tooth of a Mastodon in which there are five complete transverse ridges, this being the most complex form of tooth found in any of the Mastodons.

In certain Tertiary rocks in India lying along the southern flanks of the great range of the Himalaya there are, however, found enormous numbers of teeth of peculiar species of Elephants, which, while resembling in many respects those of the Mastodons, have a considerably greater number of ridges. Moreover, the ridges themselves are relatively narrower and taller, so that the depth of the intervening valleys is likewise increased. These valleys also contain a certain amount of the third constituent of mammalian teeth—the cement—so that their bases are partially filled up by it.

Fig. 13.—A Left Upper Cheek-Tooth of a Mastodon in an Unworn Condition.

From the teeth of these Intermediate Elephants, as they may be conveniently called, the step is very short to those of the modern or true Elephants. In these, as shown in Fig. 15, the difference from the teeth of the Mastodon is so great that without the intermediate forms it is difficult to trace the correspondence between their respective elements. In the true Elephants, indeed, the transverse ridges of the teeth have not only been greatly increased in number, so that there may be as many as twenty-five in the last tooth of certain species, but they have also been so much increased in height and narrowed in width that they assume the form of thin plates, which may be six or eight inches in height, and of which the sides are almost parallel. The valleys between these plates, as they may now be called, have likewise become thin and deep slits, which are completely filled to their very summits with the cement. Thus, comparing Fig. 15 with Fig. 14, it will be apparent that each of the elongated discs seen in the former, which consist of a layer of enamel surrounding a strip of dentine, correspond to the transverse ridges of the latter; while the space between the discs in Fig. 15, which are composed of cement, represent the open valleys of Fig. 14.

The surface of such an Elephant's tooth forms, indeed, a millstone most perfectly adapted for grinding vegetable substances, consisting as it does of parallel ridges composed of elements of different degrees of hardness. Such a tooth, with its height of nearly eight inches in some species, takes many years to wear away; and with a succession of six of these teeth gradually increasing in size and complexity from the first to the last, we are well able to understand how the Indian Elephant can live fully to the age of a century. It is also equally evident that the more simple and lower-crowned teeth of the Tertiary Mastodons must have been worn away at a far more rapid rate; so that we are justified in saying that these animals could not have attained anything like the length of life enjoyed by their modern descendants.

There is a considerable amount of variation in the structure of the grinding teeth of the true Elephants, although all of them resemble to a greater or less degree the specimen represented in Fig. 15. In the African elephant, however, the discs of dentine, surrounded by their border of enamel, are much wider in the middle than in the figured tooth, and thus assume a lozenge shape. In this respect, therefore, the African elephant is a more generalised or old-fashioned kind of animal than his Indian cousin; and we may observe, in passing, that the African continent is now remarkable for containing a number of old types, such as Hippopotamuses, Giraffes, and Aard-Varks, which have totally disappeared from other regions, although, as we know from their fossil remains, they were once widely spread over the globe. Thus, Hippopotamuses (or shall we say Hippopotami?) once ranged over the greater part of Europe, extending as far north as the southern parts of our own islands, and were also common in northern India; the same being true of the Giraffes, with the exception that their remains have not hitherto been found in Britain.

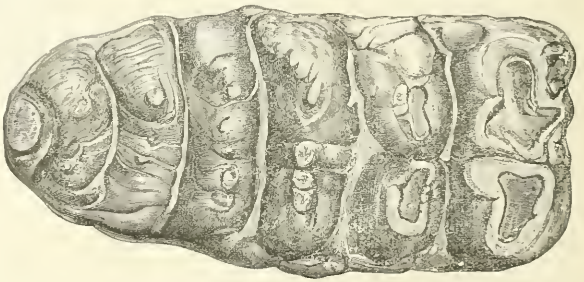


Fig. 14.—The Last Left Upper Tooth of a Mastodon, with the enamel of the two first ridges perforated by wear.

The most complex type of teeth is, however, attained by the Indian Elephant, and the closely allied Mammoth, which in the latest geological epoch ranged over the greater part of Europe, and whose frozen carcases are from time to time washed out from the so-called "tundras," or superficial deposits of Siberia, to be exposed to human view after having been buried for countless centuries. In these two species the plates of the teeth are narrower and


CEYLON.
ARTOCARPUS INCISA. (BREAD-FRUIT).

more numerous than in the tooth represented in Fig. 15, so that the even surfaces of dentine form still narrower strips. At first sight it seems difficult to believe that the Elephant now inhabiting the burning plains of India should be closely allied to a species which formerly roamed over the icy regions of Siberia, but there are two considerations which show how little value such objections have. Thus, in the first place, there is considerable evidence that the climate of Siberia, although doubtless always cold in winter, was formerly less severe than at present. We have, moreover, evidence in the case of the Tiger how an animal can support the extremes of heat and cold with no alteration of its structure. Many people, indeed, if they were asked to mention the *habitat* of the Tiger, would say India, little knowing that this creature ranges in China and thence to Siberia into extremely high latitudes. The skins of these northern tigers are far handsomer than those from India, the hair being long and comparatively shaggy, so as to protect its owner from the bitter cold. The case of the Indian Elephant and the Mammoth is a precisely similar one, the existing Indian species having, as we all know, an almost naked skin, while the Siberian Mammoth was clothed with long shaggy hair, as we learn not only from its frozen remains, but also from the rude pictures of the living animal drawn on fragments of its own tusks by the old pre-historic hunters of the Dordogne many centuries ago.

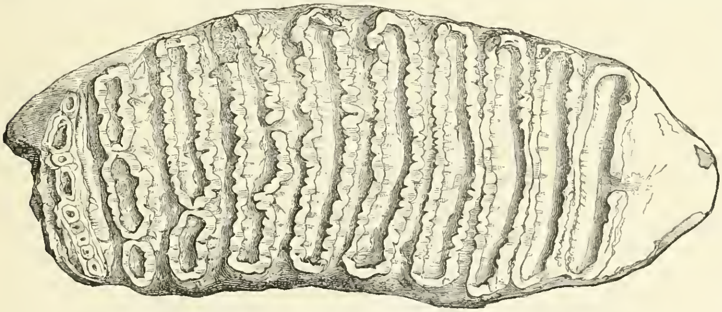


Fig. 15.—A Right Upper Tooth of an Elephant, in a Half-worn State.

In mentioning tusks, we should not forget that the modern Elephants differ from many of the old Mastodons in having tusks only in the upper jaw, while in the latter they were also present in the lower. We have, therefore, here also another instance of the greater specialisation of the recent types.

In showing that with the advance of time the Elephants have gradually developed an extremely complex type of grinding tooth from a comparatively simple one, we find that they occupy a parallel position with that held by the other two great groups of the Ungulate order.

There is, however, one very important point whereby the Elephants differ from these two groups, namely, that they have not undergone any contemporaneous modification in the structure of the foot. The foot of an Elephant is, indeed, of an exceedingly primitive type, having five complete toes, and being more like those of the very earliest Ungulates of the Tertiary period than is the case with any other living member of the order, except the little Hyrax or so-called Coney of the Bible. The explanation of this absence of modification in the structure of the foot of the recent as compared with the extinct Elephants is, however, not far to seek. By reason of their huge bulk these animals have no need to fear the attacks of other creatures, so that there was no necessity for the development of a limb suitable for extreme speed, while the huge bulk of their bodies of itself also required the retention of a type of limb constructed on principles of strength rather than elegance. Hence there has been no inducement for any alteration in the structure of the feet of these ponderous brutes as time rolled on; and so that while it requires the aid of the man of science to trace the relationship existing between the tooth of the ancient Mastodon and that of the modern Indian Elephant, the veriest tyro would not hesitate to declare that the skeleton of the same two creatures indicated the closest relationship.

To sum up the results of this brief survey of some of the more striking features connected with the cheek-teeth of the Ungulate Mammals, we may say that all the Ungulates of the lower Tertiary deposits had low-crowned teeth of comparatively simple structure; and that those of all the three groups into which the order is divided can be derived from a type of tooth not far removed from that possessed by the ancestors of the Pigs, the latter type being itself a modification from the still more primitive triangular type. In all the three groups of Ungulates, the crowns of the teeth have tended to increase in height and in complexity of structure with the advance of time; those Ungulates with the tallest crowned teeth being characteristic of the most recent period of the earth's history. Finally, that while in the groups containing the Ruminants and the Horses the structure of the feet has been modified *pari passu* with that of the teeth, to produce limbs capable of carrying their owners at an extremely rapid rate, in the Elephants, where there is no need for swiftness of flight, the feet have not undergone this adaptive modification, so that the whole structural alterations have been confined to the teeth.

In a subsequent communication we shall hope to illustrate some of the modifications of tooth-structure found in other groups of Mammals; but we venture to think that sufficient has been said to show what an extremely interesting study is that of teeth. These organs are, indeed, interesting not only from their curious and often beautiful forms, but also, as we have striven to show in the foregoing paragraphs, as affording a concise and, so to speak, epitomised summary of the degree of evolution which any particular group of animals has undergone in the course of time.

WEISMANN'S THEORY OF HEREDITY.

By Edward Clodd.

THE scientific world is becoming interested to the point of agitation about certain theories which have been broached by a very distinguished German biologist, Professor August Weismann, of Freiburg. These theories have been set forth and defended in a series of essays, issued at intervals

* *Essays upon Heredity and Kindred Biological Problems.* By Dr. August Weismann. Authorised Translation, Edited by E. B. Poulton, Selmar Schönland, and Arthur E. Shipley. (Oxford: Clarendon Press, 1889.)

since 1881, abstracts of which by Professor Moseley and others have appeared from time to time in *Nature*, and, under the title of the "Transmission of Acquired Characters," were the subject of an important debate opened by Professor Ray Lankester at the Manchester meeting of the British Association in 1887, Professor Weismann taking part in the discussion. Within the last few months the whole of Professor Weismann's essays have been collected and issued by the Clarendon Press as one of the volumes of the series of Foreign Biological Memoirs, so that the English reader has now the opportunity of learning about the last deliverances on the subject of "heredity and kindred problems" in his mother tongue. The publication of this volume gave rise to an able and, in fundamental points, adverse criticism by Sir William Turner at the Newcastle meeting of the British Association last autumn, and this has been followed by the appearance of a translation of Professor Eimer's book* on the same lines, as well as by Professor Vines's attack in *Nature*, to which Professor Weismann has replied in that journal, and by a voluminous correspondence which shows no sign of yet coming to an end. So that a considerable body of literature of the subject exists, and as the substance of what Professor Weismann has said is in scattered form not very easy to follow through the detached essays, an attempt to focus and present it in untechnical form may be of service. The learned Professor had asked himself, as every thoughtful biologist pondering over the mystery has asked: "How is it that a single microscopic cell, imbedded in the ovum of the mother, can reproduce the physical and mental features of the parents down to the minutest details, and with these, not infrequently, certain characteristics of grand-parents and of more remote ancestors?"

Several converging lines of observation and thought led him to the theory of the basis of heredity which is given in the essays, and of these the two following are the main tracks. Firstly, that death is not a primary attribute of living matter. Secondly, that characters *acquired* by the parent are *not* transmitted to the offspring.

Professor Weismann admits that the problem of the origin of life remains unsolved, and probably is insoluble; we know that life had a beginning and that it will have an end, but we know nothing more about it. The case is different, however, in respect to death. There is a vast number of living things which do not die naturally. Of course they perish through various causes; they are eaten, or destroyed by accident, by intense heat and other agencies. But so long as the normal conditions which brought them into being remain; so long as the conditions necessary to their existence are fulfilled; they neither decay nor die, having within them the power of an endless life. The organisms upon whom is thus laid no burden of mortality, with such pangs of separation, and such dread of the unknown, as are ours, lie at the very bottom of the scale of life. All livings things are, for purposes of convenience, divided into two classes: the Protozoa or one-celled, and the Metazoa or many-celled. The one-celled class includes the lowest and simplest forms, and the many-celled includes all other organisms in unbroken continuity of development, as, in animals, from sponges up to men.

Now it is the Protozoa which Professor Weismann says are alone immortal. Each Protozoon is a microscopic mass of a jelly-like substance, seemingly structureless, without apparent unlikeness or separation of parts. There is in the very simplest no body-cavity, no trace of a nervous system, but only a nucleus or minute particle near the centre. Every part of this one-celled organism does everything. Food and air are absorbed through the general surface; and locomotion through the water, in which medium it lives, is effected by pushing out finger-like processes. Although under certain conditions, as of drought or frost, it dries up, it resumes an active life when favourable conditions return. It performs an arithmetical feat in multiplying itself by division. The more it eats the bigger it gets, till such disproportion between the mass which needs food and the surface through which the food is received is reached that it divides equally, at the nucleus, into two parts. Each half becomes a complete individual, and grows in like manner till it also divides; and so on with the multiplication of Protozoa *ad infinitum*. Now it cannot be said of either half that one is parent and the other offspring, for both are of the same age, and only in a limited sense can we speak of succession of generations as the sub-divisions into separate individuals are repeated. Nor is there anything analogous to death in these processes. "There are," Professor Weismann says, "no grounds for the assumption that the two halves of an amœba are differently constituted internally, so that, after a time, one of them will die while the other continues to live. Such an idea is disproved by a recently discovered fact. It has been noticed in one of the foraminifera, and in other animals of the same group, that when division is almost complete, and the two halves are connected only by a short strand, the protoplasm of both parts begins to circulate, and for some time passes backwards and forwards between the two halves. A complete mingling of the whole substance of the animal, and a resulting identity in the constitution of each half, is thus brought about before the final separation."* Of course, as Professor Weismann points out elsewhere,† the immortality of one-celled organisms and (as will be shown presently) of the germ-cells of the Metazoa, is potential, not absolute. "It is not that they *must* live for ever, as did the gods of the ancient Greeks—Ares received a 'mortal wound' and roared for pain like to ten thousand bulls, but could not die—they can die, the greater number in fact do die, but a proportion lives on which is of one and the same substance with the others." An immortal, unalterable living substance does not exist, but only immortal forms of activity of organised matter.

Now, as the Metazoa are descended from the Protozoa, one is curious to learn how Professor Weismann explains the evolution of the mortal from the immortal, because, as we shall see, the many-celled have "put on mortality." He accounts for this by "unequal fission," in other words, the failure of certain one-celled organisms to divide themselves completely, whereby unlikeness of parts and differences of position of parts resulted. "The first multicellular organism was probably a cluster of similar cells, but these units soon lost the original homogeneity. As the result of mere relative position there arose division of labour, some of the cells were especially fitted to provide for the nutrition of the colony, while others undertook the work of reproduction."‡ Obviously, those on the outside, being exposed to the direct and constant action of their surroundings, would be the media of nutrition, and be builders-up of the cell-commonwealth. So the result of

* *Organic Evolution as the Result of the Inheritance of Acquired Characters according to the Laws of Organic Growth.* By Dr. Theodor Eimer. Translated by J. T. Cunningham, M.A. (Macmillan & Co., 1890.)

* *Essays on Heredity*, &c., p. 26.

† *Nature*, 6 Feb. 1890, p. 318.

‡ *Essays*, p. 27.

this cell-clustering would be that the cells fell into two classes, body-cells and germ-cells. While the former were concerned solely with the nutrition of the organism, losing in this specialisation of function the power of reproduction, that function became concentrated in the germ-cells, or, speaking more precisely, in the germ-plasm, "the undying part of the organism," which is located in the nucleus of the germ-cell. It is these germ-cells which Professor Weismann contends are the immortal part of the Metozoa. "It is necessary," he says, "to distinguish between the mortal and the immortal part of the individual —the body in its narrow sense (the *soma*, as Professor Weismann, applying the Greek word for body, calls it) and the germ-cells. Death affects only the former; the germ-cells are potentially immortal, in so far as they are able, under favourable circumstances, to develop into a new individual, or, in other words, to surround themselves with a new body (*soma*)."* With increasing sub-division of function, there has been increasing modification of the organism, increasing complexity of parts, but the twofold classification of the cells has remained. The death of the body-cells is involved in the ultimate failure to repair waste, because a worn-out tissue cannot for ever renew itself, and because cell-division has its limits. Death also becomes a necessity, being of advantage to the species, the needs of which likewise determine the duration of the individual life.

Now as it is impossible for the germ-cell to be, as it were, an extract of the whole body, and for all the cells of the body to despatch small particles to the germ-cells from which these derive their power of heredity—the fundamental idea, it will be remembered, in Darwin's provisional theory of Pangenesis, namely, that all the cells throw off gemmules, which ultimately become concentrated in the reproductive elements—the germ-cells, so far as their essential and characteristic substance is concerned, are not derived from the body of the individual, but directly from the parent germ-cell. Heredity, then, according to Professor Weismann, is secured by the transference from one generation to another of a substance with a definite chemical and, above all, molecular constitution, and he names this theory "The Continuity of the Germ-Plasm." This germ-plasm is assumed to possess a highly complex but extremely stable structure, conferring upon it the power of developing into a complex organism. So stable is it, that "it absorbs nourishment and grows enormously without the least change in its complex molecular structure."† Of this germ-plasm it is assumed (we find no lack of assumption) that a small portion contained in the parent egg-shell is not used up in the construction of the body of the offspring, but is reserved unchanged for the formation of the germ-cells of the following generations. "One might represent the germ-plasm by the metaphor of a long creeping root-stock from which plants arise at intervals, these latter representing the individuals of successive generations."‡

Only variations of the germ-plasm itself are inherited, and it is upon these variations that natural selection operates. (Be it always remembered that, in Darwin's own words, "unless profitable variations occur, natural selection can do nothing.") Variations are due, Professor Weismann says, to the process of reproduction by which the larger number of existing organisms are propagated. This process combines two groups of hereditary tendencies derived from the mingled germ-plasms of the male and female parents, resulting in those individual differences which form the material from which new species are produced by the action of natural selection. Those differences multiply in geometrical ratio, so that "in the tenth generation a single germ contains 1,024 different germ-plasms with their inherent hereditary tendencies, and, as continued sexual reproduction can never lead to the reappearance of exactly the same combinations, new ones must always arise."* Sexual reproduction could alone "have called into existence that multiplicity of form of the higher animals and plants, and that constantly fluctuating union of individual variations, of which natural selection stood in need for the creation of new species."†

Such, in as brief outline as lies in our power to make, is the remarkable theory which is causing no light searchings of heart among the Bereans of Evolution, and renewed study of their scriptures to see whether these things are so. The most staggering blow which Professor Weismann has dealt against current beliefs is in the denial of the transmission of individually-acquired characters which is involved in his assumption of the continuity of the germ-plasm. Certainly, if in this matter he has not proved his case, he has exposed the insufficiency of the existing evidence against it. For what he says is that the structure of the offspring depends on the germ-plasm, and as this has no break in its continuity, but remains unaffected by any changes occurring within the body cells, the structure remains identical. It matters not what may be the action of external influences, or of the use or disuse of certain organs; any changes induced thereby in the parent are not transmitted to the offspring. The parent is only the medium by which the germ-plasm repeats in the offspring the physical and mental structure of the ancestors, so that, as Grant Allen aptly puts it in his review of Professor Weismann's Essays,‡ "parent and offspring resemble one another, not because the parent produces the offspring, but because both arise from the self-same substance, which merely develops earlier in the parent and later in the offspring. To use a transparent metaphor, the father is thus reduced to the position of an elder brother to his own son." Professor Weismann restricts the term "acquired characters" to those features which make their first appearance in the individual, and which are due to mode of life different from that of its ancestors, to change of climate, variety of food, and to other agencies. To these may be added effects of mutilation. All such he classes as "somatogenic," because they follow from the reaction of the *soma* under external influences. It is these which he contends are not transmitted.

All other characters are classed as "blastogenic," because "they include all those characters in the body which have arisen from changes in the germ, and all the changes produced by natural selection operating upon variations in the germ."§

So the sum of the matter is, that natural selection is all in all, and that use and disuse, and action of the environment, count for nothing, or, perhaps, a very little, for upon this we have "two voices" in the *Essays*. The influence of the agents to which, as Darwin grew older and widened his range of observation, he was disposed to give greater weight, and the large place of which in the production of specific characters is maintained by Herbert Spencer in his *Factors of Organic Evolution*, is denied by Professor Weismann.

Our remaining space must be given to a few of the

* *Essays*, p. 122.
† *Ibid.*, p. 271.
‡ *Ibid.*, p. 266.

* *Essays*, p. 276.
† Professor Weismann, in *Nature*, 6 Feb. 1890, p. 322.
‡ *Academy*, 1 Feb. 1890.
§ *Essays*, p. 413.

leading objections which tell in favour of the older view.

1. As against Prof. Weismann's contention against the rise of new species except through the agency of sexual reproduction, there are the numerous cases of a sexual fungi which show no sign of extinction, one family, as Prof. Vines points out, "of the most varied form and habit, including hundreds of genera and species, in which, so far as minute and long-continued investigation has shown, there is not, and probably never has been, any trace of a sexual process."* And like evidence is supplied by certain wheel-animalcules.

2. So far as acquired muscular developments and mutilations are concerned, doubtless the evidence of their transmission is of the slenderest kind. Generations of dogs whose tails and ears have been docked have not produced puppies with corresponding mutilations; the children of one-eyed, one-armed, and one-legged parents are born with their full complement of limbs and eyes, nor is it proved that the offspring of blacksmiths and navvies appear with abnormally developed biceps. But although this may hold good of gross and non-vital parts, Professor Weismann has a more difficult task in contending that it also does not apply to the subtle processes which initiate changes in vital parts. Upon this it is far from easy to get at his real meaning, for his statements are "hedged" with qualifications.

In his essay on "The Significance of Sexual Reproduction in the Theory of Natural Selection" it is admitted that "the ultimate origin of hereditary individual differences lies in the direct action of external influences upon the organism."† "In what way," he asks,‡ "could the transformation of species be produced, if changes in the germ-plasm cannot be transmitted? And how could the germ-plasm be changed except by the operation of external influences, using the words in their widest sense?" But immediately after the first of these extracts, he says, "Hereditary variability cannot, however, arise in this way at every stage of organic development, as biologists have hitherto been inclined to believe. It can only arise in the lowest unicellular organisms, and when once individual difference had been attained by these, it necessarily passed over into the higher organisms when they first appeared." Turning back to the essay on "The Continuity of the Germ-Plasm," we read as follows:—"I am also far from asserting that the germ-plasm is absolutely unchangeable or totally uninfluenced by forces residing in the organism within which it is transformed into germ-cells. I am also compelled to admit that it is conceivable that organisms may exert a modifying influence upon their germ-cells, and even that such a process is, to a certain extent, inevitable. The nutrition and growth of the individual must exercise some influence upon its germ-cells, but in the first place this influence must be extremely slight, and in the second place it cannot act in the manner in which it is usually assumed that it takes place."§ The manner in which the influence acts is a matter of observation which, from the nature of the case, is beset with difficulty; that the influence is slight is of quite secondary importance, because, however small may be the effect, its repetition and accumulation through generations will give us all the proof we need of transmission of functionally-acquired characters. Really, after such admissions on the part of Professor Weismann, there seems little left to argue about, but for his arbitrary arrest of the action of external influences in organisms above the Protozoa.

That these are many-celled does not destroy the fact of their fundamental unity, or make other than incredible the theory that the germ-plasm can exist in the organs of reproduction unchanged by the variations which modify, more or less, the whole *soma*. How is the theory of an unaffected, insulated germ-plasm to be reconciled with the ceaseless manufacture, secretion, and expulsion of germ-cells which goes on through active life, the materials of which are derived from the materials which nourish the entire organism, the complexity of the cells of which may, for aught we know, be as subtle as those of the germ-cells? And, moreover, how can that theory be reconciled with the subtile influences of altered physical conditions, and especially of the nervous system on the reproductive system?

Besides this, there is a multitude of organisms in which the germ-plasm is not located in one place, but diffused throughout. Any part of a *Hydra* when cut off will grow into an entire animal; fresh plants, producing flowers and fruit, will grow from the fragments of the leaves of the *Begonia*, and Professor Eimer cites the case of a forest of young fronds which sprouted from a thallus of *Lunularia vulgaris* which had been "cut up with a sharp knife on a smooth plate of cork until the fragments were so small as to form a coarse-grained pulp,"* which was then spread on moist sand. Such instances as these, to which the familar case of the propagation of the potato through the tuber may be added, render it "difficult," as Sir W. Turner remarks, "to understand why the nutritive processes which affect and modify the soma-cells should not also react upon the germ-plasm."

3. Space forbids detailed reference to the striking experiments of Hoffmann on wild flowers, in which double flowers obtained by continuous cultivation from normal wild flowers became hereditary, and to the observations of Yung on change of sex of tadpoles by altering the nature and quality of their food,† and we must pass to what appears the chief *crux* in Prof. Weismann's theory, namely, the impossibility of reconciling psychological evolution with the continuity of the germ-plasm.

Among the most solid contributions which Mr. Spencer has made to biology in its highest aspects is his theory of the genesis of the nervous system, a theory which is confirmed by the observations of the lamented Francis Balfour and other embryologists. That system, both in man and the lower animals, had a common origin in modifications of the primitive skin due to the direct action of the environment. The irritability which characterizes the entire surface of the lowest animals gradually became concentrated in definite tracks and led to the formation of nerve-centres. "The functions of the central nervous system, which were originally taken by the whole skin, became located in a special part of the skin which was step by step removed from the surface,"‡ the brain itself "arising from an infolded tract of the outer skin which, sinking down beneath the surface, became imbedded in other tissues and eventually surrounded by a bony case."§ Here, if anywhere, seems incontrovertible proof of the origin of the structures through which we apprehend the outer world in the play of that outer world upon the superficial parts of the organism. "These structures," as Mr. Spencer says, "once commenced, and furthered by natural

* *Nature*, 24 Oct. 1889, p. 626.
† *Essays*, p. 279.
‡ *Ibid.*, p. 411.
§ *Ibid.*, p. 170.

* Eimer, p. 395.
† *Evolution of Sex*, by Geddes and Thomson, p. 41.
‡ Spencer's *Factors of Organic Evolution*, p. 66.
§ Balfour's *Treatise on Comparative Embryology*, vol. ii., p. 400 (Second Edition.)

selection where favourable to life, would form the first term of a series ending in developed sense-organs and a developed nervous system."

How serious are the issues involved is pointed out in Mr. Spencer's preface, as the following extracts show:—

If functionally-produced modifications are inheritable, then the mental associations habitually produced in individuals by experiences of the relations between actions and their consequences, pleasurable or painful, may, in the successions of individuals, generate innate tendencies to like or dislike such actions. But if not, the genesis of such tendencies is, as we shall see, not satisfactorily explicable.

That our sociological beliefs must also be profoundly affected by the conclusions we draw on this point, is obvious. If a nation is modified *en masse* by transmission of the effects produced on the natures of its members by those modes of daily activity which its institutions and circumstances involve, then we must infer that such institutions and circumstances mould its members far more rapidly and comprehensively than they can do if the sole cause of adaptation to them is the more frequent survival of individuals who happen to have varied in favourable ways.

I will add only that, considering the width and depth of the effects which acceptance of one or other of these hypotheses must have on our views of Life, Mind, Morals, and Politics, the question—Which of them is true? demands, beyond all other questions whatever, the attention of scientific men.

For this reason, Professor Weismann merits the thanks of his opponents in stimulating their inquiry into the soundness of the foundations on which their belief in the transmission of individually-acquired characters rests. Each has the fact of the continuity of generations to work upon; the rest is a question of evidence which has only recently been collected with any pretence to accuracy of record, or with any true appreciation of its profound significance. So that we have scarcely emerged from the empirical stage, and have long to wait before our material can be of sufficient volume to be of value.

Much remains to be added to give this paper any pretence to completeness of exposition, but we must supplement its shortcomings by commending to the careful perusal of our readers Sir William Turner's Address, already referred to, which is given in full in *Nature*, 26th September 1889, as also Mr. Cunningham's masterly preface to his translation of Professor Eimer's book for a series of arguments, drawn from his own researches, in support of variations through functional activity and external conditions.

THE FACE OF THE SKY FOR AUGUST.

By Herbert Sadler, F.R.A.S.

THE remarkable sunspot minimum still continues, the sun's disc for days together being entirely free from a trace of spots. Conveniently observable minima of Algol occur at 10h. 51m. P.M. on the 6th; 7h. 40m. P.M. on the 9th; and 9h. 22m. P.M. on the 29th. Mercury is an evening star, but is not suitably placed for observations by the amateur, as during the whole month he sets less than three-quarters of an hour after the sun. Venus is an evening star, setting on the 1st at 9h. 11m. P.M., 1h. 21m. after the sun, with a northern declination of 5° 2′ and an apparent diameter of $15\frac{1}{2}''$. On the 31st she sets at 7h. 22m., 0h. 34m. after the sun, with a southern declination of 10° 1′, and an apparent diameter of $19\frac{1}{2}''$. At the beginning of the month she appears as a little moon between twenty and twenty-one days old, and is then in Leo, but she enters Virgo on the 5th, and remains in that constellation till the end of the month. She does not approach any conspicuous star very closely. Mars is an evening star, though owing to his increasing southern declination and decreasing apparent diameter he will be found rather a disappointing object for the amateur. He sets on the 1st at 11h. 13m. P.M. with a southern declination of 23° 54′ and an apparent diameter of 14″. On the 31st he sets at 9h. 58m. P.M., with a southern declination of 25° 42′ and an apparent diameter of $11\frac{1}{4}''$. On the latter date his brightness is only one-third of what it was at opposition. About the middle of the month $\frac{86}{100}$ of the disc will be hidden from view. During August he passes through portions of Scorpio and Ophiuchus. At transit on the 5th he will be about 2′ due south of the $6\frac{3}{4}$ magnitude star Lacaille 6751; at 11h. P.M. on the 14th he will be about $7\frac{1}{2}'$ *n.p.* the $5\frac{1}{2}$ magnitude star 22 Scorpii; and at transit on the 30th he will be about $7\frac{1}{2}'$ due south of the $6\frac{3}{4}$ magnitude star 28 Ophiuchi. Jupiter is an evening star, rising on the 1st at 7h. 36m. P.M., with a southern declination of 19° 17′, and an apparent equatorial diameter of 48″. On the 31st he rises at 5h. 30m. P.M., with a southern declination of 20° 9′, and an apparent equatorial diameter of $46\frac{1}{2}''$. The following phenomena of the satellites occur while the planet is more than 8° above, and the sun 8° below, the horizon. An occultation disappearance of the third satellite at 8h. 55m. P.M. on 1st. An eclipse reappearance of the same satellite at 0h. 45m. 54s. on the 2nd; an occultation disappearance of the first satellite at 1h. 56m. A.M.; a transit ingress of the first satellite at 11h. 4m. P.M., and of its shadow at 11h. 9m. P.M. (see "Face of the Sky" for July). On the 3rd a transit egress of the first satellite at 1h. 24m. A.M., and of its shadow at 1h. 30m. A.M.; an eclipse reappearance of the first satellite at 10h. 46m. 41s. P.M. An occultation disappearance of the second satellite at 10h. 56m. P.M. on the 4th. An eclipse reappearance of the second satellite at 2h. 4m. 1s. A.M. on the 5th. An eclipse reappearance of the fourth satellite at 1h. 46m. 29s. A.M. on the 6th; a transit egress of the second satellite at 8h. 48m. P.M., and a transit egress of its shadow at 9h. 9m. P.M.; an occultation disappearance of the third satellite at 0h. 12m. A.M. on the 9th. A transit ingress of the first satellite at 0h. 48m. A.M. on the 10th, and of its shadow at 1h. 4m. A.M.; an occultation disappearance of the first satellite at 10h. 6m. P.M. An eclipse reappearance of the first satellite at 0h. 41m. 37s. A.M. on the 11th; a transit egress of the first satellite at 9h. 34m. P.M., and of its shadow at 9h. 53m. P.M.; an occultation disappearance of the second satellite at 1h. 10m. A.M. on the 12th; a transit ingress of the shadow of the second satellite at 8h. 52m. P.M.; a transit egress of the second satellite itself at 11h. 4m. P.M., and of its shadow at 11h. 17m. P.M. An occultation disappearance of the first satellite at 11h. 51m. P.M. on the 17th. A transit ingress of the first satellite at 8h. 58m. P.M. on the 18th, and of its shadow at 9h. 27m. P.M.; a transit egress of the same satellite at 11h. 18m. P.M., and of its shadow at 11h. 47m. P.M. A transit egress of the shadow of the third satellite at 8h. 45m. P.M. on the 19th; an eclipse reappearance of the first satellite at 9h. 5m. 19s. P.M.; a transit egress of the shadow of the third satellite at 10h. 17m. P.M. A transit ingress of the second satellite at 10h. 26m. P.M. on the 20th, and of its shadow at 11h. 29m. P.M. A transit egress of the second satellite at 1h. 21m. A.M. on the 21st. An eclipse reappearance of the second satellite at 8h. 33m. 28s. P.M. on the 22nd. A transit ingress of the first satellite at 10h. 43m. P.M. on the 25th, a transit ingress of its shadow at 11h. 22m. P.M. A transit egress of the first satellite at 1h. 4m. A.M. on the 26th; an occultation disappearance of the first satellite at 8h. 3m. P.M.; a transit ingress of the third satellite at 8h. 27m. P.M.; an eclipse reappearance of the first satellite at 11h. 0m. 24s. P.M.; a transit ingress of the shadow of the third satellite at

11h. 8m. P.M. A transit egress of the third satellite at 0h. 7m. A.M. on the 27th; a transit egress of the shadow of the first satellite at 8h. 11m. P.M. A transit ingress of the second satellite at 0h. 41m. A.M. on the 28th. An eclipse reappearance of the second satellite at 11h. 9m. 41s. P.M. on the 29th. A transit egress of the fourth satellite at 11h. 8m. P.M. on the 30th. Jupiter describes a short retrograde path in Capricornus during the month, but does not approach any naked-eye star.

Saturn is in conjunction with the sun at 7h. P.M. on the 30th. Uranus and Neptune are, for the purposes of the amateur observer, invisible; the latter planet being in quadrature with the sun on the 30th. This month is one of the most favourable ones for observing shooting stars in. The most noted shower is that of the Perseids, with a radiant point at the maximum display on August 10 in R.A. 11h. 52m. Decl. + 56°. Observations of this region of the heavens with an opera-glass will, no doubt, show stationary meteors, or meteors which shift their positions very slowly. Their place and the direction of their shift should be noted for the purpose of determining whether the radiant is a geometrical point, or a circle, or an elliptic area, as suggested with regard to the November meteors (*Monthly Notices of the R.A.S.*, vol. xlvii. pp. 69-73). The radiant point souths at 5h. 37m. A.M. The moon enters her last quarter at 2h. 19m. P.M. on the 7th, is new at 4h. 20m. P.M. on the 15th; enters her first quarter at 1h. 20m. P.M. on the 23rd, and is full at 4h. 35m. A.M. on the 30th.

At 3h. 5m. A.M. on the 1st the $5\frac{1}{2}$ magnitude star χ Capricorni will disappear at an angle of 154° from the lunar vertex, and reappear at 4h. 1m. A.M. at an angle of 303. On the 4th the $4\frac{1}{2}$ magnitude star 30 Piscium will disappear at 1h. 55m. A.M. at an angle of 170° from the vertex, and reappear at 2h. 30m. A.M. at an angle of 234° from the vertex; while at 3h. 31m. the same morning the $4\frac{1}{2}$ magnitude star 33 Piscium will disappear at an angle of 136° from the vertex, and reappear at 4h. 40m. A.M., ten minutes after sunrise, at an angle of 309° from the vertex. At 11h. 34m. P.M. on the 9th the 5 magnitude ι Tauri will make a near approach to the lunar limb. At 1h. 9m. A.M. on the 10th the 6th magnitude star 105 Tauri will disappear at an angle of 98° from the vertex, and reappear at 1h. 58m. A.M. at an angle of 215° from the vertex. The $4\frac{1}{2}$ magnitude star 1 Geminorum will disappear at 2h. 48m. A.M. on the 11th at an angle of 31° from the vertex, and reappear at 3h. 40m. A.M. at an angle of 270°. The $6\frac{1}{2}$ magnitude star B.A.C. 2238 will disappear at 0h. 56m. A.M. on the 12th at an angle of 39° from the vertex, the star being below the horizon of Greenwich at the time, and reappear at 1h. 41m. A.M. at an angle of 268°. The $5\frac{1}{2}$ magnitude star ψ Sagittarii will disappear at 6h. 1m. P.M. (in bright sunlight) on the 26th, at an angle of 90° from the vertex, and reappear at 7h. 4m. P.M., five minutes after sunset, at an ample of 225° from the vertex. The $5\frac{1}{2}$ magnitude star 33 Capricorni will make a near approach to the lunar limb at 6h. 27m. P.M. on the 28th, in bright sunlight, and at 11h. 26m. P.M. the same evening the 6th magnitude star 37 Capricorni will disappear at an angle of 47° from the vertex, and reappear at 11h. 50m. P.M. at an angle of 11° from the vertex. At 0h. 35m. A.M. on the 29th the $4\frac{1}{2}$ magnitude star ϵ Capricorni will disappear at an angle of 149° from the vertex, and reappear at 1h. 38m. A.M. at an angle of 297° from the vertex; and at 3h. 18m. the same morning the 5th magnitude star κ Capricorni will disappear at an angle of 171° from the vertex, and reappear at 4h. 10m. A.M. at an angle of 306°, the star being below the horizon of Greenwich at the time.

Whist Column.

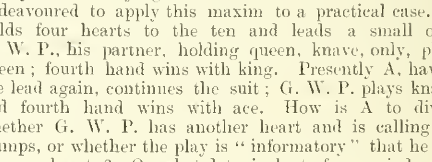
By W. Montagu Gattie.

AMERICAN WHIST—THE "NEW PLAY."

In noticing last month the new treatise by "G. W. P." on American Whist, we ventured to assert that the beginner who should endeavour to master the mysteries of the "new play," as therein set forth, would soon become hopelessly confused. Having now had time to make a more thorough examination of the book, and especially of the illustrative hands with which it concludes, we are reluctantly compelled to admit that we were wrong in restricting our remark to beginners. Entertaining, as he does not scruple to declare, a very poor opinion of English players, G. W. P. will probably not feel surprised at their failing to understand his precepts; but the fact is none the less unfortunate as affecting the value of his work in this country. From among a score of equally startling dogmas it will be sufficient to take a single example. On p. 99 we find this mandate: "Holding any two high cards in sequence and no more of the suit, upon partner's lead play the highest." We had imagined this to be the simplest and most orthodox method of indicating a desire for a trump lead. But G. W. P. goes on to say, "when the other falls, it is not a call. The play is informatory, and partner will judge as to his future lead." We have endeavoured to apply this maxim to a practical case. A holds four hearts to the ten and leads a small one; G. W. P., his partner, holding queen, knave, only, plays queen; fourth hand wins with king. Presently A, having the lead again, continues the suit; G. W. P. plays knave, and fourth hand wins with ace. How is A to divine whether G. W. P. has another heart and is calling for trumps, or whether the play is "informatory" that he has no more hearts? On what data is he to form a judgment as to his future lead? And, again, how would G. W. P. himself proceed, if he held queen, knave, and another heart, and wished to call? Or, to take a still more simple case, supposing him to play nine and then eight on his partner's lead of king and ace, would this be a call if he held the knave also, but only "informatory" if he did not? Either there must be this ambiguity, or G. W. P.'s maxim renders it nearly always impossible for third hand to call with two cards in sequence.

The following is given as a specimen of a game won by brilliant play, which, by the way, G. W. P. tells us is "very occasional" in England. We give the game (with the notes) as it stands, appending our reasons for thinking that it may also be described as a game lost by very bad play.

Hand No. 12.

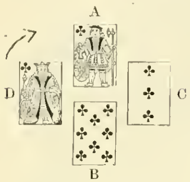


B's Hand.

Score.—AB, 6; CD, 4. [As explained last month, the American game is seven points up, and honours do not count. In this case honours are divided, and, if we place AB at 4, and CD at 2, we may consider the hand as having been played under the English code, the point being that CD require three by cards to make game.]

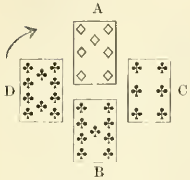
B turns up the eight of clubs.

Trick 1.



Tricks—AB, 0; CD, 1.

Trick 2.

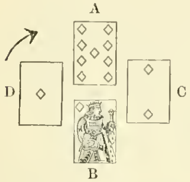


Tricks—AB, 0; CD, 2.

Trick 1.—D plays king at head of six.

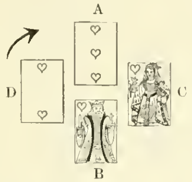
Trick 2.—C has not echoed, and does not hold both ace and seven.

Trick 3.



Tricks—AB, 0; CD, 3.

Trick 4.

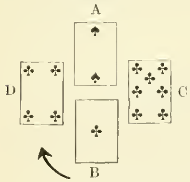


Tricks—AB, 1; CD, 3.

Trick 3.—The *coup de sacrifice*, a beautiful play.

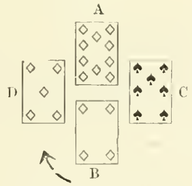
Trick 4.—The two of hearts, to throw the play, if possible, into C's hand, that on his lead D may get rid of his diamonds.

Trick 5.



Tricks—AB, 2; CD, 3.

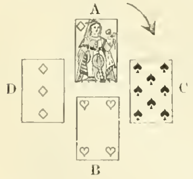
Trick 6.



Tricks—AB, 3; CD, 3.

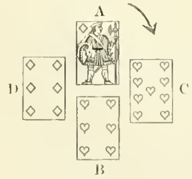
Trick 5.—B reads the six trumps of D, consequently the three of C's hand, also the five diamonds of D, and the best diamonds in A's hand.

Trick 7.



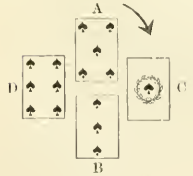
Tricks—AB, 4; CD, 3.

Trick 8.



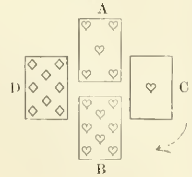
Tricks—AB, 5; CD, 3.

Trick 9.



Tricks—AB, 5; CD, 4.

Trick 10.



Tricks—AB, 5; CD, 5.

Trick 9.—C reads the rest of the trumps in D's hand, and but one spade and the last diamond, and plays ace.

Tricks 11, 12, and 13 are taken by D's trumps,

CD make two by cards, and
AB save the game.

A's Hand	B's Hand.
S.—5, 4, 2.	S.—Kg, 10, 9, 3.
H.—Kn, 7, 5, 3.	H.—Kg, 8, 6, 4.
C.—Kn.	C.—Ace, 9, 8.
D.—Qn, Kn, 10, 9, 7.	D.—Kg, 4.
C's Hand.	**D's Hand.**
S.—Ace, Qn, Kn, 8, 7.	S.—6.
H.—Ace, Qn, 10, 9.	H.—2.
C.—7, 6, 3.	C.—Kg, Qn, 10, 5, 4, 2.
D.—2.	D.—Ace, 8, 6, 5, 3.

Remarks.—At Trick 3 many players in D's position would continue the trumps. This is obviously the best course if C holds the ace. If B has it, D has still to consider that he requires two tricks at least, if not three, from C in order to make game, and that he will be giving C's cards the best chance by throwing the lead into B's hand. If B has both ace and seven (the eight and nine may not improbably have been false cards), he is tolerably certain to make them sooner or later, and, as the game can only be won by strong cards in C's hand, it is, in this case also, desirable to place the lead with B. But, as D prefers to open the Diamonds, he is surely ill-advised in abandoning the command, especially as A has shown strength in the suit by his discard at Trick 2. The lead of ace from a five-suit is correct at the commencement of a hand, but not when the trumps are mostly out, and there is no doubt that the ace will make later on. D should have opened the diamonds with the five; B, pursuing the same tactics as in the actual game, would have won his partner's trick with the king, drawn a round of trumps, and returned the small diamond. D could then have played his ace, and continued with the three, showing five originally. A's best chance would have been to lead a heart or a spade; but C, if he had counted his partner's hand would have played his two aces, and D would eventually have made game with his trumps and the last diamond. B's play of the king is clever, but we do not see that there is any certainty that A holds all the best diamonds, as the foot-note to Trick 5 implies; he may have discarded from the best protected of three four-card suits.

D's play at Trick 4 is still more open to question. Why not continue the diamonds? The worst that can happen is for B to be void of them and to make the seven of trumps, if he has it; and in that event he will have to lead spades or hearts up to C. D's aim should be to clear his diamonds, not to seek means of throwing them away. C shows himself worthy of his partner. He only discovers at Trick 9 what is perfectly clear after Trick 3—viz. that D holds queen, five, four, two, of trumps, and at least four small diamonds, and therefore can have only two other cards. Consequently he embraces the opportunity which D affords him of throwing away the game by a *finesse*. His play is the more inexcusable inasmuch as the deuce of hearts is obviously a "singleton." The best of players may sometimes fail to count his partner's hand correctly, although the hands in which such lapses occur are not usually selected for publication in a standard work; but in this instance C's play appears to us to savour of dulness as well as inattention. Knowing that B could have no trump but the ace, it was clearly his duty to make sure of Trick 4, and to return the hearts at once for D to ruff. D

might then have been nerved to continue the diamonds, and CD would have won the game easily and an extra point to boot, according to the American system of scoring. In fact, we scarcely see how CD could have played the hand worse than they did.

Chess Column.

By I. Gunsberg (Mephisto).

[Contributions of general interest to chess-players are invited. Mr. Gunsberg will be pleased to give his opinion on any matter submitted for his decision.]

The following two interesting games were played in the match Blackburne *v.* Lee, at Bradford.

Game No. 2.

White. Lee.	Black. Blackburne.	White. Lee.	Black. Blackburne.
1. P to K4	P to K4	23. Q to K3	QR to KBsq
2. Kt to KB3	Kt to QB3	24. P to KKt4 (*k*)	P to B3
3. B to B4	B to B4	25. P to R5	Q to B2
4. P to Q3	Kt to B3	26. K to B2	R to B5
5. B to KKt5	P to KR3	27. K to Kt2	Q to K2
6. B to K3	B to Kt3	28. R to Kt3	Q to Kt4
7. Kt to B3	P to Q3	29. R to KBsq (*l*)	P to QKt3
8. P to QR3 (*a*)	B to K3 (*b*)	30. Kt to Ktsq	P to B4
9 KB × B	P × B	(1h. 58 min.)	(1h. 59min.)
10. QKt to R4 (c)	Castles	31. Kt to B3	P to Kt5 (*m*)
11. Kt × B	RP × Kt	32. P × P	Kt to B7
12. Kt to Q2 (*d*)	Q to Ksq	33. Q to Bsq	Kt × P
13. P to QB3	Q to Kt3	34. Kt to K2	R(B5) to B2 (*n*)
14. P to KKt3	Kt to Kt5	35. Q × Q	P × Q
15. Q to K2	R to B3	36. R to Qsq	R to Q2
(58 min.)	(50 min.)	37. Kt to Bsq	P to B5
16. P to B3	Kt × B	38. K to B2	R(Bsq) to Qsq
17. Q × Kt	Q to R4 (*e*)	39. KR to Ktsq	Kt × P (ch)
18. P to KR4 (*f*)	Q to Kt3	40. Kt × Kt	R × Kt
19. R to R3	P to Q4 (*g*)	41. R to Ktsq	R to KBsq
20. Q to K2	P to Kt4	42. R to Kt3	R to Q7 (ch)
21. R to Bsq (*h*)	P to Q5	43. K to Ksq	R to R7 (*o*)
22. P × P	Kt × P (*j*)	(2h. 47min.)	(2h. 52min.)

White resigns.

NOTES.

(*a*) The game, so far, has proceeded on ordinary lines, but P to QR3 hardly adds effectively to White's development.

(*b*) The right reply to White's inactive move.

(*c*) If Black now plays B × B, the Knight will remain badly placed on Rook's 4th, and a loss of time in any event.

(*d*) Another move of an inactive character, and all the time Black is developing his game.

(*e*) This does not seem to be a profitable move.

(*f*) A good introduction to an attack by means of P to KKt4, &c.

(*g*) White threatened to castle; Queen's rook followed by R to Kt square; Black advances just in time.

(*h*) It is difficult to suggest a better move.

(*j*) Black boldly runs the risk of remaining with his isolated pawns should it come to an end game.

(*k*) P to B4 would lead to very interesting complications in which Black could give up the Knight.

(*l*) Black threatens R × BP.

(*m*) An excellent move by which Black gains a substantial advantage.

(*n*) Safe and sound, but Kt × QP was very tempting, but less reliable.

(*o*) A neat ending, and in harmony with Blackburne's play throughout.

The following is the third game played in the Blackburne *v.* Lee match at Bradford.

French Defence.

White. Blackburne.	Black. Lee.	White. Blackburne.	Black. Lee.
1. P to K4	P to K3	8 QKt to Q2	P to B3 (*a*)
2. P to Q4	P to Q4	9. R to Ksq	QKt to Q2
3. P × P	P × P	10. P to KR3	B to R4
4. KKt to B3	KKt to B3	11. P to KKt4 (*b*)	B to Kt3
5. B to Q3	B to Q3	12. B × B	RP × B
6. Castles	Castles	13. Kt to K5	Q to B2
7. B to KKt5	B to KKt5	14. Kt × Kt	Kt × Kt

White. Blackburne.	Black. Lee.	White. Blackburne.	Black. Lee.
15. Kt to Bsq	KR to Ksq	40. K to Kt2	R to K8
(54 min.)	(48 min.)	41. QR to K3	K to Kt2
16. Q to Q2 (*c*)	Kt to Bsq (*d*)	42. Kt to B4	R to QB8
17. B to K3 (*e*)	Kt to K3	43. R to K2	P to KKt4
18. Q to Q3	R to K2 (*f*)	44. Kt to Q3	R to Q8
19. B to Q2 (*g*)	QR to Ksq	15. P to B3	P to KKt5 (*m*)
20. P to KR4 (*h*)	Q to Kt3 (*j*)	(2h. 58min.)	(2h 57min.)
21. B to K3 (*k*)	Q × KtP	46. KR to K3	R to KRsq (*n*)
(1h. 46min.)	(1h. 15min.)	47. Kt to K5	R to R5
22. KR to Ktsq	Q to R6	48. R to Ksq	R × R
23. R to Kt3	Q to R4	49. R × R	R to R6
24. P to R5	P × P	50. Kt × BP	R × P
25. P × P	Q to B2	51. Kt to Kt4	R to B6 (o)
(1h. 55min.)	(1h. 25min.)	52. Kt × P	R × P (ch)
26. Q to B5	Q to Q2	53. K to Ktsq	R to B4
27. Q to R3 (*l*)	Kt to B5	54. R × Kt (*p*)	R × Kt
28. Q × Q	R × Q	55. R × P (ch)	K to B3
29. Kt to Kt3	P to KKt3	56. K to B2	R to R4
30. QR to Ktsq	P to QKt4	57. R to Kt2	R to R6
(1h. 59min.)	(1h. 48min.)	58. K to Ksq	P to R4
31. P × P	P × P	59 K to Q2	R to R6
32. K to Bsq	Kt to K3	60. K to Bsq	K to B4
33. Kt to K2	Kt to Kt2	(3h. 56min.)	(3h. 54min.)
34. R to B3	R to QB2	61. R to K2	K to B5
35. B to B4	Kt to B4	62. K to Kt2	R to Q6
36. B × B	Kt × B	63. R to K5	R × P
37. R to Qsq	Kt to K5	64. R × P	
38. R to B3	R to R2	drawn.	
39. QR to Q3	R to R8 (ch)	(4 hours.)	(4 hours.)

(*a*) Always a safe move in the opening.

(*b*) Blackburne is never afraid of making a risky move in the hope of creating a lively complication.

(*c*) Q to Q3 would have been better.

(*d*) Intending to make a useful counter-demonstration by Kt to K3 and Kt to B5.

(*e*) When making a rapid advance any counter-demonstration in force will compel a retreat, often with loss of time and position.

(*f*) Black wisely intends to double his rooks on the king's file before making any advance.

(*g*) White has lost two important moves, for he might have played 16. Q to Q3, followed by 17. B to Q2.

(*h*) Played for want of a better move.

(*j*) Black's tactical advantage begins to materialise.

(*k*) White had not much time to examine 21. B to B3, Kt to B5; 22. Q to Q2, R to K7; 23. R × R, R × R; 24. Q to Qsq, &c.

(*l*) Q to B3 would have, for the moment, avoided the exchange of queens.

(*m*) It will be seen that in this subtle struggle for the ending, the experience of White has told in his favour somewhat.

(*n*) Played with a view to a mate by R to KR8, but I think Kt × BP would have been a simple way of winning.

(o) Black has not handled his game to the best advantage. This move in particular is an oversight, which loses a valuable pawn, and deprives him of any chance of winning.

(*p*) White might have forced a draw at once by Kt to K7.

Contents of No. 57.

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SIMPLY WORDED—EXACTLY DESCRIBED

LONDON: SEPTEMBER 1, 1890.

CONTENTS.

VARIABLE DOUBLE STARS.

By J. E. Gore, F.R.A.S.

Variable stars are not as a rule close doubles, neither do the wider double stars include many examples of the variable class. Among the known binary or revolving double stars I do not know of a single instance—with the possible exception of 36 Andromedæ—of undoubted variation, although in some cases there exists a strong suspicion of inconstancy of light.

In speaking of double stars I refer to those which are actually seen to be double in good telescopes, for on the eclipsing satellite theory the variables of the Algol type must be considered as binary stars with very short periods, and with the component stars so close that even the largest telescopes yet constructed fail to show them as anything but single stars.

To the above rules there are, however, some notable exceptions. Perhaps the most remarkable instance of a variable star being also a close double is η Geminorum. The variability of this 3rd magnitude star was detected by Schmidt in 1865, and the reality of its fluctuations has been confirmed by Schönfeld and other observers, including the present writer. The total variation amounts to about one magnitude in a period which is somewhat irregular, varying in length from 135 to 151 days, according to Schmidt. Occasionally, however, its light remains constant, or nearly so, for several weeks at a time. The colour of the star is reddish yellow, and its spectrum a fine one of Secchi's 3rd type, a type to which many of the long period variables belong. In 1881 Mr. Burnham, the eminent American astronomer and discoverer of so many double stars, found the star to be a close double, the companion being of about the 10th magnitude and distant less than one second of arc from its comparatively brilliant primary. The difference of light is therefore about 7 magnitudes, indicating that the bright star is about 630 times brighter than the faint one. Mr. Burnham speaks of it as "a splendid unequal pair, and likely to prove an interesting system." Time will of course be required to prove the accuracy of this prediction, but should its binary character be established it will form a most interesting object, especially as hitherto no binary star has been found with a spectrum of the 3rd type.

Another variable star with a close companion is the short period variable S (15) Monocerotis. This star is the principal one of a small cluster known to astronomers as Herschel VIII. 5. The variable star, which fluctuates from about 5th magnitude to $5\frac{1}{2}$, has two faint companions of about the 9th and 11th magnitude. The 9th magnitude is distant about 3 seconds of arc from the brighter star, and the 11th magnitude about $17\frac{1}{2}$ seconds, and both may possibly have a physical connection with their primary. If the close pair are really in motion, the period of revolution must be very long, as a measure by Mr. Tarrant in 1888 shows an angular change of only 6 degrees since its discovery by Struve in 1832. The colours have been noted as greenish, and blue or pale grey. The spectrum is of the first or Sirian type. Additional interest is attached to this object from the fact that a distant companion (at about 76 seconds of arc) has been strongly suspected of variation in light from $8\frac{1}{2}$ to 12th magnitude. Observations by Mr. Tarrant in March and April 1888 tend to confirm this suspicion, as they show a difference in the estimates of its brightness of about $1\frac{1}{2}$ magnitude in about three weeks. This subject deserves more careful observation than it has hitherto received. A variable star with a variable companion would indeed be an interesting object.

A similar suspicion of variability is attached to a distant companion to the famous variable star Algol. This faint companion lies about 80 seconds of arc to the south of Algol. It was discovered in 1787 by Schroter, who suspected variation in its light; and observations in recent years tend to the same conclusion. In the early part of 1874 one observer failed to see any trace of it with a 7-inch refractor; but on September 9 of the same year, it was distinctly visible in the same instrument.* Sadler considers it probably variable from the 10th to the 14th magnitude in some short period. Three other faint companions were found by Burnham, one of them being distant less than 11 seconds from the suspected variable, which was estimated of the 10th magnitude by Burnham in September 1877, the companion being rated about $12\frac{1}{2}$ on the same evening. The others are of about the 13th magnitude, and form good comparison stars for the suspected variable, which Franks found "easy enough" with an $11\frac{1}{4}$-inch reflector on January 11, 1885, and about 2 magnitudes brighter than Burnham's companion.

The well-known variable star 68 (u) Herculis has also a tolerably close companion of about the 10th magnitude, distant about 4 seconds in 1878. Here we have also a difference of brightness of about 5 magnitudes, or a ratio of 100 to 1 in the relative brilliancy of the components.

Another interesting case is that of the well-known variable α Herculis. This is a double star with components of about the 3rd and 6th magnitudes, at a distance of about $4\frac{1}{2}$ seconds of arc. Measures of position from 1782 to 1876 show little or no change, and indicate no physical

* *Nature*, Feb. 20, 1879.

connection. Possibly the fainter companion may be much farther from us than the brighter star. The colours are orange, and emerald or bluish green, and the spectrum is a splendid specimen of the 3rd type. There seems to be some little doubt as to which of the components fluctuates in light; Sir W. Herschel and Argelander considered the brighter star to be the variable one, whereas Struve thought the variation was due to the fluctuations of the fainter component from the 5th to the 7th magnitude. It is not so easy to decide a question of this kind as might at first be supposed. Viewing a pair like this with a magnifying power sufficiently high to satisfactorily separate the components, they are seen in a small telescopic field of view completely isolated from other neigbouring stars of nearly equal lustre with which they might be compared. Observations with a wedge photometer might perhaps settle the question. Judging from the colours and spectrum, my own opinion is that the brighter star is the variable, and that possibly the fainter star may have merely an optical, and not a physical, connection with its brighter companion.

Another close double star which is almost certainly variable is Y Virginis (near 68 (i) Virginis). It seems to have no regular period, but, though usually of about the 6th magnitude, it was observed by Schmidt as bright as $4\frac{1}{2}$ magnitude on June 6, 1866. The Cordoba observations in subsequent years seem to confirm the variability, but possibly the star may remain constant in its light for lengthened periods. In 1879 Burnham found it to be a very close double star, the components being nearly of equal brightness and separated by only half a second of arc. Observations in recent years do not give much evidence in favour of orbital motion. The colour of the star is yellowish white, and the spectrum of the Sirian type.

Among variables with distant companions may be mentioned τ Cygni, to which Burnham found a 12th magnitude companion at 10 seconds; the Algol variable υ Ophiuchi, which has a very faint companion at a distance of about $20\frac{1}{2}$ seconds; υ ("Nova") Orionis, which has a $10\frac{1}{2}$ magnitude attendant at 30 seconds; δ Orionis, a 2nd magnitude star with a very faint companion at about 34 seconds, and a 7th magnitude at 53 seconds: and the short period variable δ Cephii with a 7th magnitude companion at 48 seconds.

Among stars certainly binary there is one, 36 Andromedæ (Struve 73), which is, according to Schmidt, variable to a small extent in periods varying from 40 to 125 days, but I am not aware that this variability has been confirmed by other observers. The components are of about the 6th and 7th magnitude, and the present distance between them a little over one second of arc. Dr. Doberck has computed an orbit for this pair, and finds a period of about 349 years.

Among the numerous stars which have been suspected of variable light, but which have not yet been admitted into the ranks of the regular variables, there are some interesting cases. The components of the well-known binary star γ Virginis have been suspected of alternate variation in brightness. In the years 1851 and 1852 Struve found the components sometimes exactly equal and sometimes differing by nearly three-fourths of a magnitude in favour of the southern star. In the years 1825 to 1832 he found the other component certainly the brighter. Franks found the southern star half a magnitude the brighter on March 28, 1885. Struve's suspicion seems to be confirmed by the observations of Fletcher, and the point seems deserving of more attention than it has hitherto received. An estimate of relative brightness might easily be made by those observers who measure at intervals the position of the components, and in this way interesting results might be obtained.

The companion of the double star Struve 547 has been suspected of variable light. It was estimated as $11\frac{1}{2}$ magnitude by Struve in the years 1829 and 1832; but Dembowski could not see it in 1865. Burnham, although gifted with keen eye-sight, failed to find it in 1873 and 1876. Gledhill was equally unsuccessful in 1879. The companion was, however, seen and measured by Mädler in 1845, by Burnham in 1877, 1879, 1880, and 1881, and by Gledhill in 1880. The latter observer found the distance between the components about $2\frac{1}{2}$ seconds, and his measure of angle (15·8°) seems to show some angular motion since its discovery by Struve in 1831.

A similar case is found in Struve 1058, in which the 11th magnitude companion to an $8\frac{1}{2}$ magnitude star was measured by Burnham in 1879 and 1881, but could not be found by Dembowski in 1865, nor by Burnham in 1874, 1875, and 1878.

In the double star Struve 1517 the observations of Struve, O. Struve, and Secchi seem to point to some variation in the relative brightness of the components. The measures of position since 1832 indicate a slow angular motion in the pair, which have also a common proper motion through space.

Struve 1932 is a double star in Corona Borealis, of which the components were estimated 5·6 and 6·1 magnitudes by Struve, 6 and 6·5 by Secchi, and 6·9 and 7·2 by Dembowski. Struve suspected variability, and my own observations with a binocular in the years 1885-1887 apparently show a small variation of light. The measures indicate a marked angular motion since its discovery in 1830, so that the pair is probably a binary.

The components of 36 Ophiuchi were rated $4\frac{1}{2}$ and $6\frac{1}{2}$ magnitude by Smyth in 1831. Sir J. Herschel estimated them both as 6th magnitude in 1834 and 1837. Dawes rated them both 5th magnitude in 1841, and so they were seen by Jacob in 1846. In 1854 Webb found them "nearly equal, about 6·5, Smyth's smaller perhaps rather the larger." In 1875 in India I noted them as "Both yellow, and almost exactly equal. The following star (Smyth's brighter component) if anything rather the brighter of the two." The measures show a well-marked angular motion of the pair, which is probably a binary as the components have a considerable common proper motion of about $1\frac{1}{4}$ seconds per annum. Curious to say, they are accompanied in their flight through space by the star 30 Scorpii which is distant no less than 13 minutes of arc from the binary pair.

One of the components of the double star O. Struve 256 has been suspected of variable light. They were rated 7·2 and 7·6 in 1848 by O. Struve, who made the *preceding* star in the field his primary. In 1867 Dembowski seems to have seen the *following* component the brighter, as his measures of position angle show. Perrotin in 1885 agrees with O. Struve and measured the position angle from the *preceding* star. On August 22, 1887 an occultation of the star was observed by Mr. J. Tebbutt at Windsor New South Wales. He had not at the time identified the star and was not aware that it was double. About three-fourths of the star's light at first suddenly disappeared, and about two seconds later "the rest of its light, which resembled a blurred star of the 9th magnitude, vanished quite as suddenly." This observation seems to show that on the date of Tebbutt's observation, the *preceding* star was *considerably* the brighter of the two components, and compared with Dembowski's measures, appears clearly to indicate variable light in one or other of the component stars. The pair is probably a binary.

HORNS AND ANTLERS.

By R. Lydekker, B.A.Cantab.

In a former article, entitled "Mail-Clad Animals," we treated of what may be termed the armature of animals for passive resistance; while in the present communication it is our intention to consider certain forms of armature adapted either for active resistance or for actual attack. Many forms of this type of armature, such as the tusks and claws of the Cat-tribe and other Carnivores, the pincers of the Lobster, the sting of the Bee and the Scorpion, and the poison-fang of the Adder, will at once present themselves to the mind of the reader; but on this occasion we propose to confine our attention to those types of armature commonly known as horns and antlers, which are now met with only among the Hoofed or Ungulate Mammals; although, as we shall mention in the sequel, the former were also developed in past epochs among a lower group of animals.

Fig. 1.—Head of Fallow-Deer, to show branching and palmated antlers.

It will, first of all, be essential to thoroughly understand what we mean by the terms "horn" and "antler," since, although both are purely English words, there is often great confusion in their application; the term horn being often applied to an antler, although the converse misnomer is never met with.

Commencing with antlers, it is scarcely necessary to say that the organs so named are the branching bony protuberances borne upon the heads of the males of most species of Deer during a certain part of the year. The nature of these appendages is well shown in the accompanying woodcut, drawn by Mr. H. A. Cole, from the head of a Fallow-Deer shot in Epping Forest in 1884. In the figured species the extremities of the antlers are flattened out, and are accordingly termed palmated; but in the Red Deer, and most other species, they are more or less completely cylindrical throughout the greater part of their length.

The most characteristic feature of the outer surface of an antler is its ruggedness, which reminds us somewhat of the bark of a tree, and is taken advantage of in the manufacture of so-called "buckshorn" knife-handles, &c. Antlers are, indeed, almost quite peculiar in that they represent, when fully formed, an entirely dead structure borne by a living animal as part and parcel of itself, and their mode of growth is very interesting. Thus, some time after a stag has shed its antlers, there appear on the summit of the skull two small velvety knobs, very tender and sensitive, and supplied by an unusual number of blood-vessels. These knobs, which are deposits of bony matter, very rapidly increase in size, and soon begin to branch into a number of so-called tynes, and finally assume the form of the complete antlers. It will thus be evident that even when fully grown the new antlers are still entirely covered with the soft skin known as the "velvet," beneath which the blood-vessels carry the blood to all their parts. With the final completion of their growth, and the cessation of the deposition of bony matter from the blood over the greater part of the antler, there is formed, however, at the very base above the point where the antler joins the protuberance on the forehead from which it takes its rise, a rough prominent ring of bone. This protuberant ring, which is commonly known as the "burr," and is often used to form the end of whip-handles, serves to constrict the blood-vessels at this point, so that henceforth no blood is carried over the antlers. In consequence of this deprivation of blood, the "velvet" rapidly dries up, and either peels off, or is rubbed off by the animal against the stems and branches of trees. The antlers are then complete, and their owner steps proudly forward from the sequestered glades in which he has lain concealed during the period of their growth as the "monarch of the glen."

This, then, is the mode of development of antlers; and after they have served their purpose as weapons of offence during the fierce encounters which take place between the males during the breeding season, the living bone beneath the skin at the base of the burr is absorbed, and the antler, or dead bone, is shed, to be again renewed in the same manner as before.

Another point in connection with antlers is, however, noteworthy—namely, that they gradually increase in complexity as the age of the animal advances. Thus, the head of the Fallow-Deer represented in Figure 1 evidently belongs to a fully-grown buck, for a young animal would have had much simpler antlers. Indeed, in the fawns of the first year the antlers of the Red-Deer consist only of a single prong, with a short front tyne; and year by year as they are renewed they acquire a greater and still greater number of tynes and branches, till they finally attain the complete stage, when their owner is termed a "royal hart." And a similar gradual increase in complexity takes place in the case of the Fallow-Deer and most other species. A few forms, however, like the Roe, always retain a comparatively simple type of antler, and thus recall the Deer of the middle Tertiary period, when none of the species had attained the complex antlers found in the larger living species. When we go still farther back in past time, and come to the lower part of the Tertiary epoch, we find, indeed, that the Deer had no antlers at all; and it is thus curious to observe, as in so many other instances, that the gradual annual increase in the complexity of the antlers of an individual of one of the existing species, is but an epitome of the gradual evolution during geologic times of the complex antlers of the living forms from the simple ones of their early ancestors.

Great variation occurs in the form assumed by the antlers of the different species of deer. Thus, as we have said, in the Roe the antlers are simply forked, while in the fully-developed Red Deer they may have as many as sixteen points. In the Fallow-Deer the extremities only (Fig. 1) are distinctly palmated ; but in the Elk, or Moose, the palmation embraces nearly the whole of the antler, and attains an enormous development. Of the species with cylindrical antlers those which attain the greatest development in this respect are the Canadian Wapiti, the great stag of the Thian Shan range, and some allied species from Sikkim and Persia. But the antlers which are found fossil in the peat and cavern-deposits of this country indicate that the predecessors of our own Red Deer attained equally gigantic dimensions. The extinct Irish Deer had, however, the finest antlers of any member of the family, their expanse from tip to tip exceeding 11 feet. Alone among the deer-tribe, the Reindeer of the northern regions of Europe and America has antlers in the female as well as in the male ; thus indicating that in

Fig. 2.—Skull of an Ox, showing the bases of the Horn-cores.

this instance the function of these appendages is connected with something else besides the combats of the males during the breeding season.

Having said thus much in regard to antlers, our next theme is that of horns, which we shall find to be of a totally different nature. The woodcut (Fig. 2) shows the bony skull of an extinct species of Ox, with the bases of the bony horn-cores ; the tips having been cut away in order to save space. It will be seen that these horn-cores are bony prominences arising from the forehead, without any "burr" at their base, and forming, in fact, part and parcel of the skull itself. During life they are permeated by blood-vessels which traverse the whole of their interior, and they are coated by the hollow sheaths, to which the term horn is properly restricted. In structure these horny sheaths are merely a specially modified kind of skin, somewhat analogous to our own nails ; and they are connected with the underlying horn-core by soft tissue and blood-vessels. Thus the horns of an Ox, Sheep, Goat, or Antelope, are essentially living structures—as we may see for ourselves in the case of an Ox or Cow which has had the misfortune to wrench off its horn from the bony horn-core ; and are thereby totally different from the dead Antlers of the Deer. Moreover, with one remarkable exception, of which more anon, horns are never branched, and are never shed from their bony cores. In many instances, as in the Oxen, they are also common to the male and female ; although those of the former are the larger. As in the case of Deer, however, we find that the earliest Oxen and Antelopes were devoid of horns, and that these appendages show a gradual increase in size as we ascend in the Tertiary period to the present day.

The one exception among the hollow-horned Ruminants (as the animals with true horns are often called), in which the horns are branched and are annually shed from their cores, is the Prong-buck of North America. In this elegant Antelope the horns have a single branch, and curve backwards in a hook-like manner. Another type of cranial appendage is exhibited by the well-known Giraffe, of Africa, which has a pair of short bony horn-cores on the forehead differing from those of any of the preceding forms. These horn-cores, which are some three inches in length, are cones of bone resting upon the forehead, from which in the young state they are entirely separate, although in old animals they become firmly united by bone with the skull. They are completely covered with skin, and appear to be of no possible use to their owner. They may, perhaps, be regarded as remnants of larger appendages found in certain extinct animals, which appear to have been in some respects intermediate between antlers and true horns.

The creature in which this intermediate type of cranial appendages occurs is the huge extinct Sivathere, of the Upper Tertiary deposits of Northern India, which is the largest known representative of the Ruminants, or cud-chewing Mammals. This animal was provided with huge wide-spreading antlers (although it is here difficult to say whether we should use the term antler or horn), somewhat like those of the Elk, but apparently permanently attached to the skull, since they show no "burr" at the base. These antlers were, in all probability, always covered either with skin or with very thin horn, and thus seem to indicate that the difference between an antler and a horn is not so great as appears to be the case when our studies are confined to living animals.

The last form of horn we have to mention among existing animals is that found in the Rhinoceroses. And here we have to observe that whereas the antlers of the Deer and the horns of the Oxen are placed in pairs on either side of the skull, in the Rhinoceroses the horns or horn (for there may be either two or one) are placed in the middle line—one in front of the other when two are present. In structure these horns would be comparable to the horn of an Ox, if the latter had no bony core, and were filled up internally with the same horny material as that which forms its outer surface. These horns have no solid attachment to the underlying bone, and are thus only excessive developments of skin-structure, more analogous in structure to warts than to anything else with which we can compare them.

The extinct animals from the tertiary of the United States known as Titanotherer, which were somewhat akin to Rhinoceroses, are distinguished by having a transverse pair of bony horn-cores above the nose, which during life were doubtless sheathed in horn. Again, the Uintatheres, of the same region, were another type of huge Ungulates, having as many as three pairs of bony horn-cores ; and thus being the most extraordinary creatures of this group of animals at present known to us.

The above are the three great types of the offensive armature with which the skulls of existing Mammals are provided, and they are all of them, as already observed, found in the order of Hoofed Mammals, and nowhere else, at the present day. If, however, we go back to the long-distant Mesozoic epoch, or period, at which our chalk was deposited at the bottom of the sea, we find that certain herbivorous species of the gigantic reptiles known as Dinosaurs (of which we hope to speak in a future article) were provided with paired bony horn-cores on their skulls, so exactly resembling those of our own Oxen that some of them when found detached were actually described as belonging to an extinct Bison. In the later Tertiary beds of Australia, we also find a huge tortoise with somewhat similar horn-cores on its forehead; and since these horn-cores, both in this and the preceding instance, so closely simulate in structure those of the Oxen, we may fairly infer that they were similarly sheathed with true horns during life.

Thus we learn that in long past epochs not only was the place of the larger herbivorous Mammals of the present day taken by various forms of giant herbivorous reptiles, but that those reptiles were actually armed with weapons precisely similar to those of the Mammals of the present day. So true is it that there is "nothing new under the sun."

OLD HINDU ALGEBRA.

IN India, at the time of Ârya-Bhaṭṭa 1,700 years ago, minus quantities were distinguished by a dot over the coefficient, all unmarked quantities being held to be positive or plus. Multiplication was indicated by a dot between the factors; and division by placing the divisor under the dividend, much in our own way; but squares, cubes, unknowns, &c., were indicated by initial letters of the words expressing the ideas, thus—

v for *varga* = square.
gh for *ghana* = density, cube.
gu for *guna* = multiplication.
rû for *rûpa* = form, the definite quantity.
&c. &c. &c.

Coefficients were placed *after* the literal symbols; and an unknown quantity was generally expressed by *y*, the initial of *yâvat-tâvat*, "this-much-that-much," or "any-much." Other unknowns to any number were expressed by initials of the names of colours. An instance will show the use of these symbols; thus for—

$$12\, x^2 + \tfrac{2}{3}\, x^3 - 3\, x^2 \frac{1\, x^3}{x^2}$$

the ancient Hindus wrote—

$$yv\ 12\ ygh\ \tfrac{2}{3}\ yv\ \dot{3} \cdot \frac{ygh\ 4}{yv\ 1}$$

Their method of writing an equation was more awkward than ours, and while everything else is so obvious the reason for it is not apparent; thus for—

$$12\, x^2 - 3\, x^3 = 14$$

they would write—

$$\begin{matrix} yv\ 12 & ygh\ \dot{3} & r\hat{u}\ \ 0 \\ yv\ \ 0 & ygh\ 0 & r\hat{u}\ 14 \end{matrix}$$

The second line is given as the equivalent of the first line, ciphers being supplied where required.

FREDERIC PINCOTT.

WHY IS THE SEA SALT?

By W. MATTIEU WILLIAMS.

(*Continued from p. 179.*)

IN my last I described the variations in the degree of salinity of the ocean, and the causes of such variation, and concluded by reference to the apparent paradox that the river-flows which are reducing immediate local salinity are the main sources of the general salinity.

The paradox vanishes when we consider the fact that the ocean simply occupies the lower valleys of the earth, and that the dry land consists of its mountain summits and their upper slopes only. This portion of the earth slopes towards the main or oceanic valley, and thus all the drainage and washings of the exposed land surface proceed to the ocean. The insoluble portion of these washings are deposited as ocean-bed strata, the soluble portions remain in solution in quantity dependent on their solubility. River-water or spring-water, as we all know, is more or less "hard," but the rain-water, from which all these hard waters are derived, is "soft."

The hardness of the hard water is due to saline impurities held in solution; the softness of soft water, to the absence of these. The ocean is being continually distilled by solar heat, and the distilled water, thus lifted into the atmosphere and falling on the earth as rain, is pure, soft, or free from saltness. Therefore the saline materials which give hardness to the river-water are derived from the land, and must be left behind in the sea.

It is true that the quantity of such saline matter dissolved in the water that enters the sea at the mouths of rivers is very small, but "many a mikle maks a mukle," and this everlasting supply of small contributions that has been going on as long as the surface of the earth has consisted of land and water, is amply sufficient to account for the *quantity* of salt in the ocean.

If this explanation is correct, a confirmation should be found in all inland bodies of water, all lakes and seas that have no outlet. The great Canadian lakes, the lakes of Constance, Geneva, &c. are merely outspread rivers—streams that pour into a deep, wide valley at one end and run out of it at the other. Thus, the Lake of Geneva is but an outspread of the Rhone, the Lake of Constance an outspread of the Rhine. But there are other lakes with no such lower outlet—lakes that only retain their normal level (as the ocean does) by evaporating as much as they receive from rain and the river or rivers that supply them. As they thus receive hard or slightly saline water and give off only soft or pure water, they should represent the ocean in respect to salinity. This is the case. Many are more strongly saline than the sea itself. This is especially the case in hot countries, where the amount of evaporation is great.

The Dead Sea is a popular example of this. It occupies a deep trough-like valley, and receives at one end the famous river Jordan, and at the other, and from its sides, a multitude of minor rivers and rivulets. The whole of this surplus supply of water is removed by solar distillation; the amount of such distillation varying—other conditions being equal—with its surface. As the land is sloping on all sides, the height of the lake cannot increase without a corresponding increase of surface and consequent increase of evaporation. Thus an automatic regulation is perpetually maintained. If the river supplies diminish, the area of surface of the lake and the amount of evaporation diminish, and *vice versâ*. The excessive briny saltness of this lake is well known and easily accounted for by the above explanation.

Such model oceans are especially abundant on "the Roof of the World," that great table-land of Asia, extending northward from the Himalayas and their eastward extensions to the Altai Mountains, &c. A detailed map of this strange country is dotted over with figures, of tadpole shape, or of bags with strings attached. The strings are rivers, the bags are salt lakes, most of them of briny saltness. Many are surrounded with salt deserts, evidently the beds of their ancient greater extension. I suspect that during the great European glacial epoch, when there was more rain and less evaporation, these cul-de-sac lakes were united to form a great Asiatic Mediterranean sea. The Sea of Aral and the Caspian are larger examples of the same series. The saltness of these is commonly supposed to indicate their former communication with the ocean; but their surroundings contradict this, and what I have explained above removes the demand for the geographical violence involved in the supposition. Even if we assume that the Caspian was formerly connected with the Black Sea, it was still beyond the reach of ocean or even Mediterranean salt, as the Black Sea pours outwards through the Bosphorus into the Sea of Marmora, and this still outwards through the Dardanelles, all downwards to the Mediterranean.

Many analyses of sea-water have been made, the results displaying notable variations, as I have already stated. The following present an approximate average, as selected by Dr. Miller:—

	British Channel.	Mediterranean.
Water	964·744	962·345
Chloride of sodium	27·059	29·424
Chloride of potassium ...	0·766	0·505
Chloride of magnesium ...	3·666	3·219
Bromide of magnesium ...	0·029	0·556
Sulphate of magnesia ...	2·296	2·477
Sulphate of lime	1·407	1·357
Carbonate of lime	0·033	0·114
Iodine	traces	—
Ammonia	traces	—
Oxide of iron	—	0·003
	1000·000	1000·000

In quoting these (the first is by Schweitzer, the second by Usiglio), I should add that all such statements of analytical results involve a certain amount of hypothesis. The existence of the elements there named are demonstrated as fact, and also their quantities; but the mode of their grouping as compounds is merely inferred. Thus some of the chlorine which is there given to the sodium, the potassium, and the magnesium, may be actually associated with the calcium, and a corresponding amount of the sulphuric acid described as combined with the lime may be actually associated with soda. The further discussion of this is not demanded here, and the subject is still obscure; but there is one remarkable and highly instructive feature which exists independently of the hypothetical assumptions. It is this: *the materials most abundant in the saline constituents of sea-water are just those earth materials that are the most soluble in distilled water.*

Every student who has gone through his first practical lessons in chemical analysis knows that, with one exception, he precipitates all the metals by causing them to form insoluble compounds, this exception being sodium, and that in ordinary course he finally estimates this as soluble chloride, which he evaporates down to dry crystals. This (our common table-salt) is the leading, the characteristic salt of sea-water. There is another base that forms equally soluble salts to those of soda, viz. ammonia, but this is not a constituent of the inorganic rock material of the earth's crust, and therefore its comparative absence rather favours the general view I am advocating,

Still more elaborate analyses than those I have quoted have been made, analyses conducted for the purpose of discovering quantities too small to be detected by ordinary means. Very large quantities of sea-water have been evaporated down and the above-stated constituents removed. By skilful application of this principle the obscure, excessively diluted constituents have been concentrated and rendered evident. Thus have copper, silver, gold, and many other metals been found in such quantities as to suggest that, if we proceed far enough, we may find all the materials of the earth dissolved in sea-water in proportions bearing some relation to their solubility and their abundance on the earth's solid surface. For example, Sonnenstadt found $\frac{9}{10}$ of a gramme (about 14 grains troy) of gold in every ton of sea-water. Otherwise stated, eight tons of sea-water contain, within a small fraction, the same quantity of pure gold as we have in an English sovereign. Therefore, taking the whole weight of the ocean in tons and dividing by eight, we have the value of the gold dissolved in the ocean expressed in pounds sterling.

The saltness of the sea has been attributed to the solution of beds of rock-salt. This I believe to be just the converse of the truth. The sea has not obtained its salt from such deposits, but such deposits have obtained their salt from the sea or inland salt-lakes. The salt occurs more or less admixed or interstratified with marine or lacustrine deposits, indicating the existence of an ancient sea or lake bottom from which the salt water has been evaporated, forming first a salt-lake, then brine pools, and finally the existing saline strata.

I visted the "Salines" or salt-mines of Bex in Switzerland many years ago, travelled a considerable distance underground, expecting to see some of the glistening crystal walls and grottoes of which I had read as displayed in salt-mines; but, instead of these, found nothing but long dark passages and galleries cut in dingy, grey, mud-like rock. This is a characteristic example of such saline deposits. They usually consist of dirty sulphate of lime intermingled with grains of salt. The salt is obtained therefrom by dissolving it out with water and then evaporating the solution. When the water reaches it by natural infiltration salt-springs and salt-wells are formed, and the supply is obtained by pumping from these. Such is the case in Cheshire, Droitwich, &c.

Now let us see what would occur if we were to fill a tank with ordinary sea-water, and evaporate away the pure water. The first observable result would be general turbidity. On examination we should find this turbidity to be due to the gradual precipitation of sulphate of lime (plaster of Paris), which, being the least soluble of all the salts named in the above analyses (excepting the carbonate), would be the first to come down in notable quantity. Next to this, and simultaneously with its continuation, would occur the deposition of crystalline grains of chloride of sodium, the other salts following. If the water had been taken from the deep sea and perfectly clear, the saline rock thus formed would be white and glistening; if from estuarine shallow turbid water, it would be darker or more or less dirty, like the rock matter at Bex. That it should usually be thus dirty is only what is likely to occur under the conditions of silting up and shallowing that must accompany the isolation and evaporating down of a body of sea-water or salt-lake water.

THE BED-BUG.—I.

By E. A. Butler.

It has already been pointed out that the migrations of some insects are largely dependent upon the commercial enterprise of nations, and that it is to our own widely extended commerce that we can trace the introduction into this island of our kitchen pest, the common cockroach. We have now to consider another and much less desirable importation, which we owe to a similar source. The bed-bug, though now, unfortunately, firmly enough established, is not indigenous here, and appears to have been known as British for about the same length of time as the cockroach, although it is, of course, impossible to assign a definite date for its introduction. Like the cockroach, it appeared first in seaport towns, whence it spread to other parts; but its advance to inland regions was slow, if we may judge from a *brochure* entitled *A Book of Buggs*, written by John Southall in the year 1730, in which he points out that at that date, *i.e.* nearly two hundred and fifty years after we first hear of the insect, though "not one seaport in England is free from them, in inland towns buggs are hardly known." The earliest record of its occurrence in Britain is to be found in a Latin treatise on *Insects or Minute Animals*, by Thomas Mouffet, published in 1634. This writer, who does not state whence he obtained his information, says that in the year 1503, two ladies of noble family, residing at Mortlake, became greatly alarmed at finding themselves one morning bug-bitten, not knowing the cause of the inflamed swellings which had appeared upon their persons, and thinking they had contracted some frightful contagious disease. That even at this early date the insects were not entirely unknown, though certainly strange, appears from the ease with which the disquietude of the noble sufferers was allayed by their physician, who was at once able to point out to them the real cause of their disfigurement.

The inelegant monosyllable we are now accustomed to use as the name of this horrid parasite does not seem to have been applied to it at first; even Mouffet, who speaks of it in Latin as *Cimex*, gives as the English equivalent of this, "wall-louse," but does not mention the word "bug" at all. This, however, is only negative evidence; and as there appears to be an undoubted reference to the insect under the shorter name in a play of Massinger's dated twelve years earlier than Mouffet's treatise, it must have been at least in occasional use at that period. "Chinch" is another old name for it, which appears to have become extinct only a generation or two ago.

The origin of the modern name is somewhat obscure. As applied to the insect, the word "bug" has usually been supposed to be identical with the old British word of the same form, meaning a hobgoblin, or nocturnal apparition, a word still existing in the compound "bugbear"; and the idea was that the name was transferred to the insect in consequence of its nocturnal and disgusting habits, and the alarm they occasioned when, as in the instance above referred to, the cause was unknown. But, as Dr. Murray points out in the new English Dictionary, this is mere conjecture, and no direct evidence of the transference of the name is forthcoming; hence it is safer to regard the etymology of the word, as applied to this and other insects such as the May-bug, &c., as at present unknown. In Shakespeare the word occurs several times, in the sense of a spectre, but never as the name of the parasite, which, indeed, does not appear to be mentioned by that observant author, a tolerably good indication that it was not very common in his time. Southall, indeed, maintains that when he wrote, bugs had been established in England only for about sixty years, which would throw their first appearance down to the year 1670; but this idea is plainly refuted by the notes of time already mentioned.

To English entomologists the bed-bug is now known as *Acanthia lectularia*; it is the insect which Linné called *Cimex lectularius*, a name by which it is still frequently spoken of. *Cimex* was the name by which it was known to the Romans, and hence was selected by Linné as the generic term for bugs in general; the specific name *lectularius* is derived from the Latin word for a couch or bed, and of course refers to the locality in which we most frequently meet with it.

Though annoying us in the same way as the flea, the bed-bug is yet a totally different sort of insect, and in its life history departs as widely as possible from its companion bedroom pest. The flea, it will be remembered, we regarded as a sort of wingless fly, and therefore located it in the order Diptera; the bug, on the other hand, belongs to the order Hemiptera, and finds some of its nearest allies in the plant bugs, water scorpions, water boatmen, skaters, &c. The most fundamental distinction between these two orders lies in the nature of the metamorphosis. The Diptera, or Flies, as we have already shown, pass through the usual changes in the course of their development, appearing first as a grub or maggot, next as a limbless, motionless chrysalis, and then as the perfect fly; but the Hemiptera or Bugs, pass through no such remakable alterations of form, and in their early life show a general resemblance to what they will ultimately become, differing from the adult chiefly in size, and depth of coloration, and in the absence of wings and the immature condition of the reproductive organs. Thus, while the young flea, when hatched from the egg, is a wriggling, worm-like creature, without limbs, and utterly unlike its parents, the young and newly hatched bug is a six-legged running creature, to all intents and purposes a miniature reproduction of its parents, and a forecast of what it will itself in a few weeks become. Hence fleas and bugs, though alike in blood-sucking habits, and human parasitism, are yet almost at opposite poles in the series of developmental types.

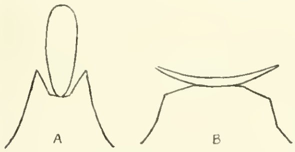


Fig. 1.—Diagrammatic Section of Body of (a) Flea, and (b) Bed-Bug.

In the form of the body, again, there is the strongest possible contrast between these two parasites. Both are extremely narrow in one direction, and broad in another; but in the flea, the body is extended vertically and contracted laterally, and in the bug it is extended laterally and contracted vertically; the former is *compressed*, the latter *depressed*. Fig. 1, representing diagrammatically a vertical transverse section of the two insects, strikingly shows this difference. The extremely depressed and flattened form which the bed-bug exhibits is by no means exceptional in the order Hemiptera, in fact this order contains amongst its species by far the flattest of all insects; "B flat" is a sobriquet not more applicable to the bed-bug than to several other kinds that are not parasitic at all. Such flatness is always associated with the habit of hiding in cracks and crevices—a habit in which, everyone knows, our bedroom pest is a perfect adept. In flatness, however, it does not equal a certain wild British species which lives under the bark of willow-trees, and has a body of almost paper-like thinness.

The disgusting odour which attends the bed-bug would

alone be sufficient to excite repugnance and to prevent its habits from being much studied. But as this smell completely goes off after death, there is nothing but the natural prejudice against a personal parasite, and one so closely associated with uncleanly conditions, to render a careful examination of the dead insect an unpleasant experience. There are many delicate touches in the portraiture even of an insect which, when alive, is so repulsive; it is not all coarseness and vulgarity, and the compound microscope, the use of which is necessary to make out the minuter details, reveals many interesting features.

For examination the insects may be killed by being plunged into *boiling* water, or by being exposed for a time to the fumes of chopped laurel leaves. In either case, their sickening smell soon disappears. Even at their largest, they are not more than a quarter of an inch long, and hence are too small and delicate to be touched with the fingers without great risk of damage, and a pair of fine forceps is necessary for handling them. When fully grown they are of a deep rust-red, tinged with black here and there in the abdomen. The head and fore-parts are somewhat lighter than the rest of the insect. Of the three divisions of the body, the head (Fig. 2) is the smallest; its hinder part is of an oblong shape, broader than long. The eyes form projecting knobs at the sides, and the base of the mouth organs a considerable prominence in front, whereby the head, as a whole, acquires roughly a pentagonal outline.

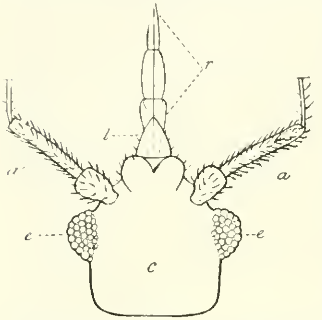


FIG. 2.—HEAD OF BED-BUG, WITH ROSTRUM EXTENDED. *a*, antennæ; *c*, crown; *e*, eyes; *l*, labrum; *r*. rostrum.
N.B.—The last joint of the antennæ and part of the next have been removed.

The mouth organs form a sort of beak, called the *rostrum*, and this, as is usually the case in the Hemiptera, is tucked back underneath the head (Fig. 3), running along the central line as far as the base of the first pair of legs, the head being slightly grooved beneath for its accommodation. At its junction with the head, the rostrum is more flexible than elsewhere, so that it can be brought out from the position of rest and held either pointing vertically downwards, or even sloping forwards, when required to be used. By reason of the constant presence of such a beak-like apparatus as this, the name Rhynchota, *i.e.* beaked insects, is frequently used instead of Hemiptera as the name of the order. Lapping over the front of the beak, at the spot where it joins the head, is a triangular plate, the labrum, or upper lip (Fig. 2, *l*). The beak itself (Fig. 2, *r*) consists of a three-jointed, tubular, or rather gutter-shaped organ—the labium—the channel of which is closed above (*i.e.* on the surface which is forward-looking when it is in use) by a thin transparent membrane, which is easily ruptured. Within the channel lie, side by side, and perfectly free, four fine, straight, bristle-like organs, which represent the mandibles and maxillæ of other insects. The mouth is therefore of the suctorial type, and suited only for feeding upon liquids; but it is adapted, not solely for sucking up exposed juices, as is that of butterflies and moths, nor for licking them up like that of bees, but for getting at liquids which are enclosed within covers or boundaries which need to be pierced before their contents can be reached. There is thus no power of biting, strictly so called; hence the term "bug-bite," like "flea-bite," is somewhat inexact.

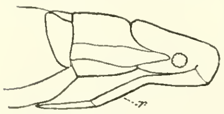


FIG. 3.—SIDE VIEW OF HEAD OF BED-BUG, showing position of rostrum (*r*) in rest.

In the presence of this boring apparatus, the whole order of bugs agrees with many of the flies, notably with gnats and mosquitoes, whose piercing bristles create so much pain by the minuteness of the punctures they make in our skin. Notwithstanding the general agreement, however, there is one strongly marked difference between the two orders; flies always have one pair of palpi and sometimes two, attached respectively to the maxillæ and the labium, but no such organs are ever found in bugs; hence the mouth in the Hemiptera is of a simpler construction than in the Diptera, through the suppression of parts which are, except in this order, almost universally present, and generally very prominent. This suppression and simplification is the more remarkable because the bugs are in some respects a more primitive race of insects than the flies, and might so far have been expected to show a more generalised type of mouth. It is impossible at present to do more than speculate as to the significance of this absence, as separate organs, of parts which are in most insects amongst the most prominent of the food-taking apparatus, and which are endowed with such a power of persistence, so to speak, that in some cases they remain distinct after the organs to which they belong, and of which they are appendages, have become fused with the rest, or have disappeared altogether. Too little is yet known of the function or functions of palpi in general, to be able to imagine what can be the influence upon the economy of the insects of the defect under which they labour. One would think that by contrasting the habits of the not-palpi-possessing Hemiptera with those of the palpi-possessing Diptera, it would become possible, by detecting constant differences between the two orders, to arrive at some valid conclusion as to the function of these organs. Such, however, does not seem to be the case, and if there is any marked difference in the way of taking the food, or in other respects, it has yet to be discovered; we know no more why the blood-sucking mosquito should possess palpi, than why the equally blood-sucking bug should be without them. Some maintain, however, that the channel-like beak itself consists of the fused labial palpi instead of the pair of jaws to which they belong, in which case the above remarks would lose some of their force.

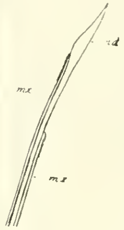


FIG. 4.—PIERCING APPARATUS OF BED-BUG. *md*, mandibles; *mx*. maxillæ.

Of the two pairs of bristles (Fig. 4) one (the mandibles) is considerably stouter than the other (the maxillæ), and the latter are exceedingly fine and delicately saw-like at the free end. Each mandible possesses a sort of flange, along which the corresponding maxilla slides, and thus the four bristles unite into one boring weapon. As everyone knows, the wound this weapon can inflict is, at least in some cases, exceedingly painful and productive of considerable inflammation. Not that any poison is instilled

into it, so far as appears, but the very minuteness of the punctures seems to be the cause of the irritation, just as a prick with an exceedingly fine needle often causes intense pain.

(To be continued.)

ON SOME RECENT ADVANCES IN THE MAPPING OF THE SOLAR SPECTRUM.

By A. C. Ranyard.

THE third volume of the *Annals of the Nice Observatory* has just appeared, accompanied by an atlas of 17 plates, in which M. Thollon's beautiful drawings of the solar spectrum have been represented by carefully executed steel plates, engraved and published at the expense of M. Bischoffsheim. The atlas represents the fruits of between six and seven years close application of a man of remarkable ingenuity and exceptional gifts; and the engraver, with the aid of M. Perrotin, the Director of the Nice Observatory, has been occupied for more than three years, since the death of M. Thollon, in reproducing the drawings.

M. Thollon's map of the spectrum was made with a large bisulphide of carbon spectroscope kept at an even temperature by water circulating within the table on which it was mounted, and also within a large double-walled metal box which descended from the ceiling and covered the instrument. The light of the sun was thrown from a heliostat on to the slit of the collimator which passed through one side of the metal box, and the observer looked through a telescope passing through the other side of the box. All adjustments of the prisms and other internal parts were made by rods and cords passing through the sides of the box, while cold water was constantly kept circulating around the instrument. With this spectroscope M. Thollon made his chart of the spectrum extending from the Great A group at the red end of the visible spectrum to *b* in the blue green. The maps put together are more than ten metres long, and contain more than three thousand lines. Not only was the position of each line carefully determined, but its thickness and blackness and the character of its nebulous edges were portrayed with conscientious accuracy, and its behaviour was studied when the sun was at different altitudes. Each portion of the spectrum is represented by four bands, the upper one of which represents the solar spectrum as observed when the sun is at a distance of 80° from the zenith and the air is neither very dry nor very damp. The second band represents the spectrum as seen when the sun is 60° from the zenith and the air is very damp. The third band represents the spectrum as seen when the sun is 60° from the zenith and the air is very dry. The fourth band contains all the lines of exclusively solar origin, and has been constructed by prolonging the lines which remain unaltered under varying atmospheric conditions.

At the time when M. Thollon commenced his mapping of the spectrum, and up to the time of his death, he did not imagine that photographs would so soon be taken which would show all the detail which can be seen by the eye with a spectroscope of large dispersion. It would have been impossible to photograph with his bisulphide of carbon prisms, though they gave a much more brilliant spectrum than can be seen with similar dispersion and a grating spectroscope, for during the time necessary to expose a plate slow changes of temperature would sufficiently alter the refractive index of the bisulphide of carbon to shift the place of the lines on the sensitive plate, and the photographic action of light in a great part of the region mapped by M. Thollon was very slow with the processes then known.

In 1880 Prof. H. A. Rowland, of Johns Hopkins University, a brilliant young American physicist and mathematician, devised a plan by which he was enabled to overcome the chief practical difficulties which mechanicians had up to that time encountered in cutting accurate micrometer screws. This enabled him to succeed in ruling diffraction gratings containing up to 43,000 lines to the inch, without an appreciable periodic error amounting to the hundred-thousandth part of an inch, and it almost entirely got rid of the ghosts which were so frequently seen overlying the spectra thrown by the earlier gratings. These were due to the recurrence of groups of narrower and broader spaces at periodic intervals which gave their own spectrum, and caused ghosts of the more prominent lines sometimes on both sides of them.

In 1881 the happy idea occurred to Prof. Rowland that a diffraction grating might be ruled on a spherical surface, and that by this means the spectrum might be brought to a focus without any lenses, thus reducing the spectroscope to its simplest form, and avoiding the cumbersome adjuncts of collimator and viewing telescope, as well as greatly facilitating physical researches in the parts of the spectrum where it had hitherto been found necessary to use rock salt or quartz lenses.

In 1886 Prof. Rowland completed and published copies of a photographic map of the normal solar spectrum, taken with one of his concave gratings of six inches in diameter and $21\frac{1}{2}$ feet radius. It extended from wave-length 3680 to 5790; that is, from above H down nearly as far as D. The region in the neighbourhood of H is on four times the scale of Angström's map; the region at the less refrangible end is on twice the scale, and the intermediate portion is on three times the scale of Angström. The definition was so good that 1474, b_3, and b_4, are shown clearly as double, and E, though not distinctly split, can be easily recognised as double. In 1889 Prof. Rowland published a new series of photographs of the spectrum, extending from wave-length 3000 to wave-length 6950, which showed a distinct advance in definition on the former series.

Another very marked step in advance has been made by Mr. George Higgs, of Liverpool, to whom we are indebted for the beautiful photographs of the portions of the solar spectrum which accompany this paper. He has made use of one of Prof. Rowland's concave gratings of four inches diameter, with a radius of curvature of 10 feet 2 inches, which gives less than half the dispersion of the $21\frac{1}{2}$-feet grating used by Prof. Rowland; but the photographs he has obtained are decidedly sharper, and show more lines than those of Prof. Rowland. For instance, Mr. Higgs counts 22 lines between D_1 and D_2 on his original negatives. I have recently made a visit to Liverpool to endeavour to learn something of the means by which Mr. Higgs has obtained such sharp definition. It seems to be owing to extreme care in making his adjustments, and to the very fine steel-jawed slit which Mr. Higgs has made for his instrument. He has been occupied for some years with experiments on the photography of the solar spectrum, and has made an extended series of experiments on the dyes for sensitive plates which enable photographs to be taken in the infra red and ultra violet regions, and he now proposes to publish a photographic map of the spectrum, extending from wave-length 2990 to wave-length 8500. Each section will be photographed coincidentally with some other portion of the spectrum belonging to a different order, so as to give a natural scale, by which any possessor of the photograph may determine the relative wave-lengths of the lines

shown. This necessitates the photographing of two differently coloured regions of the spectrum on the same plate, and greatly adds to the difficulty of the problem of selecting suitable dyes.

Practically all that is ordinarily required is the relative wave-length; from it the absolute wave-lengths may be determined when we know the absolute wave-length of any line. One of the most thorough investigations of an absolute wave-length has been made by Mr. Louis Bell, of Johns Hopkins University. He gives the wave-length of the D_2 line as 5890·188 tenth-metres, which exceeds the measure as obtained from Thalén's correction of Angström's value by about one-fifth of a tenth-metre. Prof. Rowland has followed this by a table of the relative wave-lengths of about 450 standard lines based upon Bell's investigation. He gives the wave-length of—

C = 6563·042	D_1 = 5896·156	D_2 = 5890·188	
K. 1474 = 5316·877		E_1 = 5270·497	E_2 = 5269·720
b_1 = 5183·798	b_2 = 5172·867	b_3 = 5169·159	b_4 = 5167·580
G = 4293·245			

The spectrum as photographed by Mr. Higgs is on about one-fourth the scale of the enlargements shown in the illustration. Four portions of the spectrum are given on each plate. The reader may possibly be confused by two different regions having been placed adjacent to one another, but the line of junction separating the two regions will easily be seen; they were placed in contact so as to lose no room and get as much of the spectrum on to the page of KNOWLEDGE as possible.

Section 1 represents the Great B group. Most of the lines in this group are certainly telluric, as well as in the curiously similar group Great A, which has been photographed by Mr. Higgs, but is not given in our plates. These groups are so curiously similar that one is tempted to suspect some harmonic relation between them; but there are no similar groups in other parts of the spectrum, although a region corresponding to much more than two octaves of wave-lengths has now been photographed. The first line in what has been termed the head of the B group is triple, as seen in Mr. Higgs's negatives, and it can be just recognised as triple in our plates. The tail is a fluting, consisting of several pairs thinning off and mixing with other solar lines. At 6930 there is a group of five lines, the first and fourth of which belong to the fluting, and increase markedly in blackness with a low sun, becoming much more conspicuous than the true solar lines.

Section 2, the D line region. This portion of the spectrum has been photographed by Mr. Higgs with dry plates stained with erythrosine and cyanine, which greatly increases their sensitiveness to the green and orange region of the spectrum, and has enabled him to photograph all the lines which can be seen with the eye, a result which had not been before obtained. Cyanine adds sensitiveness to the ordinary bromo-iodine dry plates down to the infra red regions. Many interesting experiments have been made with respect to such colouring substances by Mr. Higgs. He finds, for instance, that in the neighbourhood of the A region the sensitiveness may be increased a thousandfold by staining with some of the dyes of the anthracene series.

This group embraces the D lines, and the two so-called rain-bands (wave-length 5914 to 5926 and 5940 to 5960) close to it. Most of the lines in the rain-band groups, and certainly ten of the lines between D_1 and D_2, are due to aqueous vapour in our own atmosphere. With a high sun these atmospheric lines are much reduced in intensity, and some appear to vanish altogether. The spectrum here reproduced was taken with the sun from 10° to 15° high. 5884 is a double line on the original negative. One of its components is atmospheric, the other solar; and coincident with an iron line; the same remark applies to 5914·3. One of the components of each is consequently variable, while the other is constant.

Midway between the two D lines is a nickel line, but the other lines between the D_1 and D_2 have not yet been matched with laboratory spectra. Mr. Higgs has taken photographs showing the extreme faintness of the telluric lines during a keen frost; even with a low sun this seems to be strongly confirmatory of their being due to aqueous vapour.

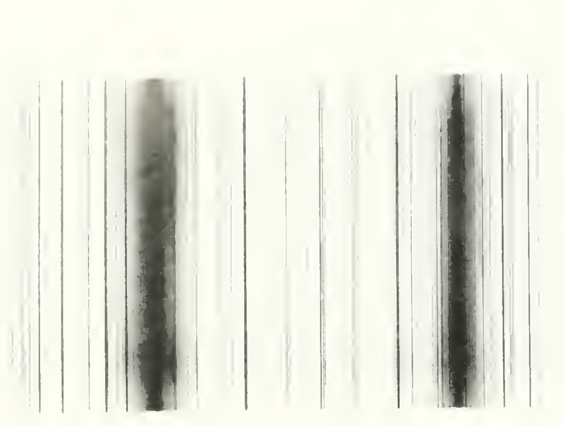
Photography will enable the position of the lines visible in the spectrum of the setting sun to be registered as never would have been possible by the laborious method pursued by M. Thollon; their number seems to increase almost indefinitely as the last limb of the sun sinks over a sea horizon. I have on more than one occasion watched the spectrum of the setting sun at sea with a hand spectroscope, and been reminded of the spectrum of a red star, so entirely does the character of the solar spectrum change owing to the added lines and absorption bands.

Section 3, the E group and adjacent lines. Peculiar interest attached to this group, as on the original negatives not only is the E line divided but also the line at wave-length 5264·4, which is twice as close. Both Angström and Kirchoff give this as being the position of a line common to both iron and calcium; but the duplicity of the line in the solar spectrum suggests that possibly the two elements have not even a vibration in common. It has been customary with some speculative physicists to speak of two elements having a common line in their spectra, as if they were thus shown to be not elementary, and were proved to be built up of still more elementary substances, one of which was thus proved to be common to both of them; but the fact that some parts of two molecules have a common period of swing, no more proves them to be identical than a violin is proved to be identical with a trombone because they are both capable of sounding the same note. It should rather be taken as proof that under particular circumstances there is some common ratio in the architecture of the two molecules, or some similar ratio between stresses and distances, which may be altogether different in the two molecules—but there is no such thing in spectroscopic analysis as proving two lines to be identical; a higher dispersion may at any time show that lines which were believed to be identical are really distinct. In this case there is only a difference of wave-length between the two lines which amounts to $\frac{1}{50000}$ths of the whole wave-length.

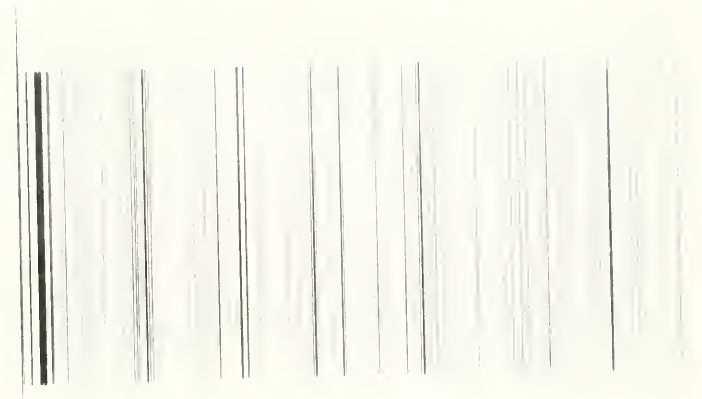
The duplicity of K. 1474 is another case in point. It is shown distinctly double in the plate, Section 3, at wave-length 5316·9. It was at first spoken of as an iron line, and theories were formed as to the existence of this one iron line in the corona. Prof. Young first saw that the dark line was double in the solar spectrum; and afterwards, during the eclipse of 1870, identified the coronal line with the chromosphere line, which he had already identified with the component of 1474 that does not belong to the iron spectrum. b_3 is another case in point; on the maps of Angström and Kirchoff it is marked as a line common to magnesium and iron, but it is now seen to be a double line.

Section 4, the G region. This is a most difficult region of the spectrum to draw, owing to the vast number of lines it contains; one can hardly put a pin's point down anywhere than on a line dark or faint, broad or narrow, but the photographic plate registers them all just as readily

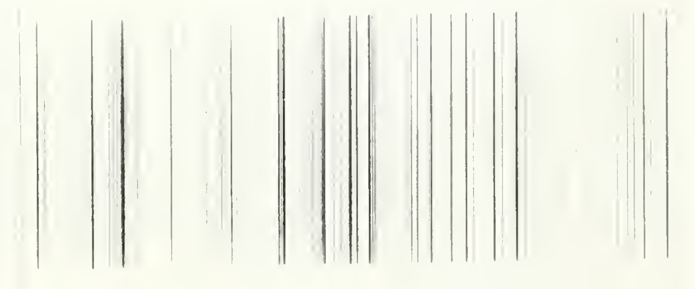
6. The K and H Lines, formerly known as H_1 and H_2.
Region wave-length 3910 to 3990 tenth-metres.



8. Region between P and O.
Wave-length 3350 to 3125 tenth-metres.



5. Region between H and h.
Wave-length 3390 to 4060 tenth-metres.



7. Region L and K.
Wave-length 3850 to 3925 tenth-metres.

One tenth-metre equals one ten-thousand-millionth of a metre.

PARTS OF PHOTOGRAPHIC MAP OF THE NORMAL SOLAR SPECTRUM MADE BY MR. GEORGE HIGGS.

Direct Photo Eng. Co., Limited, 9, Barnsbury Park, N.

1. Great B Group.
Wave-length 6830 to 6980 tenth-metres.

2. The D and Rain-band Group.
Wave-length 5830 to 5980 tenth-metres

One tenth-metre equals one ten-thousand-millionth of a metre.

3. The E Group and 1474 Lines.
Wave-length 5255 to 5330 tenth-metres.

4. Great G Group.
Wave-length 4230 to 4330 tenth-metres.

PARTS OF PHOTOGRAPHIC MAP OF THE NORMAL SOLAR SPECTRUM MADE BY MR. GEORGE HIGGS.

as it registers the appearance of a region poor in lines. There are three or four narrow spaces in this region of the spectrum which look very like bright lines, and it is difficult to convince oneself that they are not brighter than the rest of the background of the spectrum. I am inclined to agree with Dr. Draper that they are actually brighter spaces in the solar spectrum. There are similar bright spaces in the portion of the spectrum shown in Section 7, near to wave-lengths 3884 and 3888.

The nebulous K and H lines, shown in Section 6, are seen to contain a great number of fine lines which are, however, not symmetrically arranged with respect to the centres of the nebulous bands, and therefore probably cannot be regarded as forming a group associated with the hazy lines on which they happen to lie.

The concave grating used by Mr. Higgs is mounted on one side of a circular table, ten feet two inches in diameter. The sensitive plate on which the normal spectrum is thrown is at the opposite extremity of the diameter of the circular table, and the slit is also mounted on the circumference of the circle, in a position with respect to the grating and sensitive plate which varies according to the order of spectrum which is being photographed. The light of the sun is thrown by a heliostat upon the slit. In most positions of the slit more than one order of spectrum falls upon the plate at the same time, the red region, say, overlapping the violet region of another order. In order to obtain a photograph of one of these spectra, say the lines in the red region, the blue light of the other spectrum is cut out by a bath of absorbing liquid placed in front of the slit. When all but the one spectrum is eliminated, the actinic action at one end of the plate will be sometimes as much as fifty times as great as that at the other end; and if both ends of the plate were exposed for the same period, the one end of the spectrum would be greatly over-exposed when the lines at the other end were just beginning to register themselves on the plate. To avoid this difficulty Mr. Higgs makes use of shutters within the camera, moved by clockwork, which can be adjusted so that different portions of the plate are exposed for different periods. Possibly on another occasion I shall be able to give further details as to some of the ingenious appliances which Mr. Higgs has devised to facilitate his work.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

To the Editor of Knowledge.

Sir,—The following note on "Recurring Decimals" of the form $abc \ldots ka_1 b_1 c_1 \ldots k_1$ where $a + a_1 = b + b_1 =$ &c. $= r - 1_1$ if $r =$ the radix; consisting of two equal periods of n figures, P & Q supplementary to each other—may interest your readers.

1. Let $S = \cdot P\dot{Q}$

$$\therefore \quad r^n S = P \cdot Q\dot{P}$$

$$\therefore (r^n + 1) S = P + 1$$

$$S = \frac{P+1}{r^n+1}$$

$$\text{thus } \cdot 142\ 857 = \frac{142+1}{10^3+1} = \frac{143}{1001} = \frac{1}{7}$$

All fractions whose denominators are divisors of $r^n + 1$ belong to this class;

$$\text{thus } \frac{1}{10^1+1} = \frac{1}{11} = \cdot 0\dot{9}$$

$$\frac{1}{10^2+1} = \frac{1}{101} = \cdot 00\ 9\dot{9}$$

The divisors of $10^3 + 1 = 1001$, are 7, 11, 13, so that $\frac{1}{7}$, $\frac{1}{13}$, &c., belong to this class, &c.

2. All fractions of the form $\frac{1}{nr-1}$
   (1) belong to the above;
   (2) the recurring figures can be immediately obtained by multiplying from the end by n;
   (3) or by dividing from the beginning by n.

These methods were first pointed out by me in *Nature* for 1878, page 291.

Thus $\frac{1}{19} = .052631578\ 947368421$

and can be at once written down
(1) by multiplying by 2 from the end, the last figure being unity;
(2) by dividing by 2 from the beginning on a similar plan;
(3) or by writing down one period by either of the above ways, and adding the supplementary period.

Knowing $\frac{1}{nr-1}$ we can at once write down the period for $\frac{nr-2}{nr-1}$ by subtracting the former from unity or 9 in our scale.

Thus	$\frac{1}{19}$ =	·052631578	947368421
∴	$\frac{18}{19}$ =	·947368421	052631578

We observe here that the supplementary period simply comes first, and, its last figure being unity, we are able to perform the Hibernian feat of *beginning* in the *middle* and working towards the left by multiplying by 2, or towards the right by dividing by 2. R. Chartres.

To the Editor of Knowledge.

Sir,—Your article in Knowledge for May is just to hand, and in regard to your quotation of my remark (p. 130) that "many of the rays join two volcanic centres," I think you will see that this is correct. Neison, on p. 77, says "in some cases the rays end sharply at a crater, or ring plain." On p. 314 he says: "On the west many light streaks unite the two systems of Copernicus and Kepler, . . . north-east a great bundle of long, thin, very intense streaks unite the two systems of Aristarchus and Kepler," and this feature is referred to in other places. I should hardly have risked such an important "statement" on my own responsibility.

With regard to rays being due to snow *deposited* from air "*cooled by radiation*," after issuing from long radial fissures, might I point out that air—warm or cold—could hardly issue into such a void so gradually as is implied; such an issue would, almost necessarily, be of an explosive nature.

To this I attribute the formation of the nimbi or bright (often rayed) patches around some craters, see p. 24 of my theory—*i.e.* to the discharge at rare intervals of some air or gases charged with aqueous vapour.

The fact that craterlets, crater cones, and rows of confluent craters are so generally seen on the line of clefts, is a fairly good proof that, if due to exhalation of aqueous vapour, they must pass down to the warmer and moister *substrata*.

In conclusion, may I point out that the narrow band of increased brightness, round the limb, so well seen in the photographic prints in Knowledge of October last, would more probably be due to light reflected to us from cliffs than hill-tops. If the hills were flat-topped especially, the light would (at full moon) be reflected from, and not towards, our earth; and it is because this band is so well seen at full moon that I take it the light comes from cliff-faces, or the *slopes* of hill-tops.

Sibsagar, Asam, India, S. E. Peal.
July 21, 1890.

[It certainly cannot be said that most of the rays join volcanic centres—Mr. Peal's theory would not apply unless they all did. As to the air only issuing from deep clefts in the soil by reason of underground explosions, one would expect to find convection currents constantly in action bringing warm air to the surface over a vertical vent when the walls at the bottom are warm compared with the rocks above. I agree with Mr. Peal as to the sides of the mountains being visible on the moon's limb, and did not intend to suggest that we looked vertically down on the mountain-tops. The narrow band of brightness seen on the moon's limb shows that the higher parts of the mountains with their sloping sides and cliffs are all whiter than the lower ground. This must either be due to their natural colour or to snow. The snow-caps would no doubt descend in the form of glaciers, as they do upon the earth, leaving the mountain-tops bare, if the snow were not continually replaced by aqueous vapour carried upward in the thin lunar atmosphere.—A. C. R.]

To the Editor of Knowledge.

Dear Sir,—Is the following of sufficient general interest to warrant an answer in your columns? Supposing a fast and a slow ball to be hit in cricket with equal force, and in exactly similar manner, back over the bowler's head, which will travel farther? I have maintained that as there is a greater impetus to be overcome before the fast ball commences its return journey, the distance it is carried will be less than in the case of the slow ball; but I can find hardly anyone to agree with me, my opponents generally basing their opinions on "observation." Some of them attempt to account for what they believe they have observed, by remarking that the elasticity of the bat would drive back a fast ball farther than a slow one. I should like to have a disinterested theoretical opinion about it, if you do not consider it outside the scope of your magazine. Apologising for troubling you.

I am Sir, yours faithfully,

St. Leonard's. W. W. E.

"W. W. E." does not give all the data that are necessary to answer his question. Everybody is familiar with the fact that a slow ball rebounds to a less height from a floor than a ball thrown down more rapidly, and the fact is not affected by the floor being elastic as well as the ball. Consequently, if the ball were "blocked" by the batsman firmly holding the end of his bat on the ground, the fast ball would return fastest, and the velocity of return would bear a constant ratio (depending on the elasticity of the bat and the elasticity of the ball) to the velocity with which the ball was delivered. When the ball is struck in the usual manner, the velocity of the bat will be most reduced by the fast ball at the instant when the ball is reduced to rest, as well as at the instant when the ball leaves the bat, if there is no muscular force applied to the bat in the interval; but we must know the weight of the bat as compared with the weight of the ball, as well as the way in which the force of the batsman's arm is applied—as he continues to urge the bat forward after the ball has been reduced to rest—before we could attempt to calculate the velocity of the return of the fast ball, as compared with the return velocity of the slow ball. It is evident that a fast ball would be returned more rapidly, from a pendulum weighing some tons, than a slow ball which hit the pendulum in exactly the same part of its swing. But from a pendulum so light as to be nearly reduced to rest by the blow of the fast ball, the slower ball would return most swiftly.—A. C. R.

Messrs. Longman and Co. wish me to state that the publication of the parts of the *Old and New Astronomy* has not come to an end. Part XI. has occupied me much longer than I expected. I am, however, now at work upon the last sheet of it, and hope to pass it for press in the course of the next week. Part XII. and the Index will, I hope, follow shortly.

We learn from a Californian paper, which Mrs. Proctor has forwarded to us, that some citizens of San Diego propose to found a Proctor Memorial Observatory on the summit of Mount San Miguel, a mountain peak overlooking the town of San Diego. Mrs. Proctor writes to us from the Lick Observatory, where she has been stopping as a guest of Mr. Burnham, after completing a successful lecturing tour in California.

A star showing a bright line spectrum which differs from that of any other star showing bright lines has been discovered at Harvard. It is of the 9·3 magnitude, and its position is R.A. 19h. 31·9m., decl. + 30° 19′.

Notices of Books.

A Handbook of Descriptive and Practical Astronomy, Vols. II. and III. By George F. Chambers, F.R.A.S., Oxford Clarendon Press. Volume II. deals with astronomical instruments—the telescope and its accessories, telescopic stands, transit instruments, and the forms of observatories. A valuable history of spectroscopic astronomy, which has been revised by Mr. Maunder, occupies nearly a hundred pages. Volume III. is devoted to stellar astronomy, and contains a very great number of valuable lists and references. Mr. Chambers has always made the compilation of such lists and catalogues a feature of his books; and they greatly add to the value of this book as a work of reference. His list of large achromatic telescopes, his bibliography of star catalogues, and his chronology of astronomical discoveries, in the second volume, are all very valuable. Unfortunately the printers have made some strange mistakes in printing the third volume, having intermixed the catalogue of Red Stars and the catalogue of Binary Stars in a way which must be very annoying to the author. Part of the catalogue of Binary Stars seems to have been left out, and part intermixed with the Red Star chapter. Page 321 is followed on the other side of the leaf by page 290.

Birds' Nests, Eggs, and Egg Collecting. By R. Kearton. (Cassell & Co.) This is a most attractive little book, clearly printed, and very tastefully got up. Of the plates it is impossible to speak too highly; they are models of colour printing, and are both artistic and natural. There are sixteen of them, each representing nine eggs, so that about half the British species are figured. In his introductory remarks, Mr. Kearton teaches the egg collector to

pursue his hobby thoughtfully, keeping one eye on the egg and another on its surroundings, that their mutual bearings may be noted, and the causes of peculiarities, if possible, traced out. Under such circumstances, it is the more to be regretted that no attempt has been made at classification, the eggs being described simply as they occur in the plates, where they are arranged with a view to artistic effect rather than to affinity. The descriptions might easily have been arranged according to some system of classification, and we venture to think that thereby a really beautiful book would have been made considerably more valuable.

British Fossils, and where to seek them. By Joseph W. Williams. (Swan, Sonnenschein & Co.) This new volume of the marvellously cheap "Young Collector Series," maintains the reputation its predecessors have deservedly gained, and well supplies a want that every tyro must often have felt. "What to look for, and where to look"—the two burning questions that perplex the amateur fossil-hunter when he sallies forth, hammer and bag in hand, to explore a new district—these form Mr. Williams' text, and in terse language he endeavours to solve the difficulties, by pointing out where each formation is best developed, and detailing the characteristic fossils of each. He has thus produced a *multum in parvo*, which no young collector can afford to be without, and which should prove a valuable pocket companion in the field. The illustrations are numerous and good, especially of the fossils of the older formations. Workers in the Tertiaries would probably have been grateful for a few more figures of the abundant Mollusca of the period.

The Story of Chemistry. By Harold W. Picton, B.Sc. (Wm. Isbister.) In this useful and compendious handbook we have a clear and simple account of the progress of chemical research from the times of the alchemists to the present day. Mr. Picton wisely makes no assumption of initial technical knowledge on the part of those whom he addresses, and his book is, in the main, as intelligible to the general reader as to the student or the specialist. It is in itself a wonderfully fascinating tale, this, of the long struggle through the centuries between the human intellect and Dame Nature, till, after many unfruitful efforts, her secrets were finally, one by one, wrung from her grasp. But one of the most attractive features of the "story," as the author tells it, is the judicious proportion and the apt connection in which the biographical element has been introduced. To the ordinary student, the great discoverers in chemical science are too often little more than names; Mr. Picton has invested them with a living personality; he has not been so intent on detailing the gradual growth of the solid mass of facts which form the modern chemist's inheritance as to leave out of sight the human agencies by which the triumphs were achieved. We are shown what sort of men they were whose names figure so largely in ordinary text-books of chemistry, and in consequence the additional interest of life is imparted to the science which deals with dull, dead matter. Those who are puzzled by the interdependence of the facts of chemistry, and have found it difficult therefore to realise how the foundations of knowledge were laid down, will appreciate the service Mr. Picton has rendered in clearly detailing, and yet compressing within moderate limits, the story of the progress of discovery and the course by which the essentials of chemical truth were established.

Museums and Art Galleries. By Thomas Greenwood, F.R.G.S. (Simpkin, Marshall & Co.) This companion volume to the author's *Free Public Libraries* ought to be in the hands of all who are practically concerned with the advancement of the Museum and Art Gallery movement, and will, we trust, help to stimulate public interest in these invaluable adjuncts of the Public Library. With commendable industry, Mr. Greenwood has compiled a mass of information about the various Museums and Art Galleries of all characters scattered throughout the United Kingdom, as well as the chief ones on the Continent and in America. Some additional chapters are devoted to such very important branches of the subject as the "Classification and Arrangement of Objects," "Sunday Opening," "Museum Lectures," &c. We would specially call attention to the latter subject. There can be no doubt that the utility of a Museum or Art Gallery is immensely increased by the establishment in connection with it of series of good lectures on different groups of the objects exhibited; and provided the two main difficulties of suitable lecturers and necessary funds can be got over, no institution of the kind should be considered complete without some such provision. The author urges the adoption, whenever practicable, of the "Public Libraries Act," arguing that the only remedy for the neglect under which most of them suffer, and the unsatisfactory condition under which they exist, is to be found in adopting the Act, and making them rate-supported. But he neglects the educational effect of the interest called forth in those who subscribe and associate themselves together for the management of such institutions. He is perhaps inclined to over-estimate the ethical influence of Museums and Art Galleries on the holiday-making section of the community. It would appear to be sounder policy to advocate their establishment as a means of intellectual culture for a class which, though very important to the community, does not generally look to the rates for help, and had better not be encouraged to do so unless it is willing to accept the control by the State, as well as State-aid, with its attendant red-tape and stereotyped methods.

Northern 'Ajlûn, "within the Decapolis." By G. Schumacher, C.E. (A. P. Watt.) Herr Schumacher has already made his mark as a painstaking and able explorer by the work he has done as a member of the staff of the "Palestine Exploration Fund." His operations have been carried on in the northern part of the "country beyond Jordan," and several memoirs detailing the results have, during the last few years, been published by the "Fund." The present modest little volume forms a further contribution to the topography and archæology of that region, issued under the same auspices. To none but Palestinian experts will the title be likely to convey much information—a matter of no great consequence, however, as the book is evidently intended rather for students of the antiquities and ancient history of the Holy Land than for the reading public generally. Under the name "Northern 'Ajlûn," Herr Schumacher includes a small district of about 220 square miles in extent, lying S.E. of the sea of Galilee, and immediately south of the river Yarmuk, and therefore just beyond the limits of the region which has achieved notoriety as the site of the "Giant Cities of Bashan." It is interesting chiefly as being part of the Decapolis of Biblical times, and as containing the township of Umm Keis, which is believed to be on the site of the ancient Gadara. A detailed description of the ruins in this neighbourhood is given, showing the situation and form, so far as can be ascertained, of theatres, temples, and tombs belonging to the city which Josephus describes as "a place of strength, containing many rich citizens." A plan of the site is added, and many neat and careful drawings show plans and details of the ruins, accompanied in every case by all needful measurements. The

next most important group of ruins explored was at Beit Râs, which, correcting a previous identification, Herr Schumacher is inclined to think may represent the ancient Capitolias. The chief material of which the ruins are composed in all parts is the soft friable limestone of the district; hence the remains are not in such good preservation as the hard basaltic structures of Bashan. At Irbid (Arbela) large numbers of dolmens were discovered, several of which are figured. By clearing away the soil from the interior of some, masses of ashes and decayed remains of bones were revealed, apparently suggesting that these curious structures were used sometimes as places of sepulture. A well-filled and plainly printed map, and notes as to the present condition, population, and industries of the district are further features of interest, adding to the value of what appears to be a carefully executed piece of work.

THE MARINER'S COMPASS: ITS ERRORS AND THEIR CAUSES.

By R. BEYNON.

THE constancy of the mariner's compass in indicating a north and south direction has long furnished poets with an emblem of undying devotion and fixedness of affection. Modern science and research, however, go far to prove that under certain conditions the compass is far from being an infallible guide. It is true that these deviations of the needle are all consequent upon the operation of the natural laws of magnetic attraction and repulsion; but in our present state of knowledge the exact part played by these disturbing forces is not accurately known.

Since the adoption of iron and steel as shipbuilding materials, the difficulty of guarding against local attraction has been vastly increased. Such importance is now attached to these errors of the compass that it is regarded as an axiom, amongst navigators, "never to regard the compass as infallible, but only as a means of carrying the ship safely from one observation to another."

When an iron or steel ship is in process of building, a definite magnetic character is impressed upon her—*i.e.* the ship, as a whole, becomes a gigantic magnet. This sub-permanent magnetism, as it is called, is at first very erratic and uncertain in its action; but twelve or fifteen months' voyaging serves to rob it of its unstable character, and render it constant. But this is not the only needle-disturbing influence that the compass adjuster has to correct. The magnetic influence of the earth will naturally induce in a ship a magnetism that will, in north latitudes, have its north-seeking pole at that part of the ship nearest to the north magnetic pole of the earth. From this it follows that the upper parts of vertical iron, such as the upper edges of the funnel, ventilators, &c., being farthest from the magnetic lines of force, will be charged with south-seeking magnetism, and will, when the ship is north of the magnetic equator, attract the north-pointing end of the needle. At the magnetic equator itself the effect of vertical iron will be neutralised by the equal attractive influences of the north and south magnetic poles of the earth. South of the equator, however, vertical iron will be charged with induced magnetism that will repel the north-seeking end of the needle. The influence of this vertical iron is the great enemy to thorough reliability of the compass, as its effects vary with the latitude. The deviation caused by horizontal iron—or quadrantal deviation, as it is termed, from its effects being different in different quadrants—does not present the same difficulties to the corrector as does vertical iron. The quadrantal error is nearly constant, no matter what the latitude; so that when once it is properly corrected, that correction suffices.

An almost perfect instrument for compensating quadrantal deviation has been invented by Chevalier Peichl, of the Austro-Hungarian Navy. It consists of a number of soft iron rods disposed round the compass, so that their interior ends form an ellipse, of which the major axis is parallel to the keel. Above this system of rods is another which may be moved independently of the other. The action of this corrector is due to the induction of the compass needles on the soft iron rods. An index and scale provides for the varying of this inducted power consequent upon change of latitude. The sub-permanent magnetism of the ship and the effect of vertical and horizontal iron are pretty thoroughly compensated for when the vessel's compasses are adjusted. The principle involved is merely an adaptation of the old law, that the only method of destroying the effect of one magnetic disturbing force is to introduce another magnetic force which follows the same laws and has the same magnitude, but always acts in the opposite direction.

There yet remain many accidental compass-disturbing influences that require the utmost watchfulness on the part of navigators. A consensus of opinion would appear to obtain among practical men, that a compass elevated on a pole, to an altitude above the vessel's main deck equal to her beam, is free from the disturbing influences of the magnetism of the vessel's hull. Such a compass, when corrected for the vertical iron of the funnel, &c., forms a useful check upon the standard compasses placed upon the deck or bridge. Even with this safeguard, however, recent research shows that the compass corrections cannot be absolutely relied on. When a ship steers upon the same course for any length of time, it is found that a certain magnetism is induced in the vessel as a whole. This "transient-induced" magnetism, as it is called, differs from the sub-permanent magnetism which the vessel acquired while upon the stocks or in the building dock, in that its character is stable only so long as the vessel continues upon that course. A few hours' steaming in another direction serves either to annihilate or to materially change its nature. We have seen that the sub-permanent magnetism is constant, owing, no doubt, to the fact that the hammering of the plates and rivets transformed what was originally "transient-induced" into stable magnetism. This transient force may be induced in a vessel by her lying in one position in dock for a considerable length of time. All attempts to provide an adequate corrector for this disturbing influence have hitherto proved abortive, and the only safeguard of the navigator is constant observation and careful notation of the results for present and future use. "Transient-induced" magnetism dies away completely twenty-four hours after altering the heading of the ship. Probably the error of the compass thus caused is accountable for the apparently inexplicable stranding of vessels that leave port when thickness of weather precludes the possibility of observing landmarks, &c. It will be readily seen that the carrying of mineral cargoes must occasionally have a great influence upon the directive powers of the needle; and it is in such cases as this that the true value of a pole compass, which is practically removed from the chaos of disturbing magnetic forces that obtain on the lower part of the ship, is seen. When the custom of carrying large consignments of crude petroleum first came into practice, many shipmasters averred that the mineral matter con-

tained in the oil was a prolific source of compass error. Subsequent experience, however, has neither disproved nor substantiated this opinion. Now that the petroleum trade has assumed such enormous developments, this is a phase of the subject which requires investigation, and can only be solved by mariners recording in detail the conduct of the compasses when placed in close juxtaposition with such a cargo. The influence of land masses, when vessels are engaged in cruising in close proximity to the coast, is undoubtedly a *bonâ fide* source of compass deviation, the importance of which cannot be over estimated. Many rocks contain large masses of iron in one form or another which must exercise an attractive or repellent influence upon the compass needle brought near them. The results of many recorded observations show that magnetic rocks in the northern hemisphere attract the north-seeking end of the needle, while south of the magnetic equator the contrary effect is produced. Red sandstones, as containing ferruginous matter in the form of a colouring oxide, produce considerable deflection upon the needle brought near them. But it may be argued that it is very rarely that a ship would approach so near a shore as to come within the zone of magnetic disturbance. This is true. But at the same time the ship, while sufficiently distant from the land to preserve her compasses intact from deflection caused by horizontal attraction or repulsion, may yet be separated vertically, by but a few fathoms, from rocks of the same nature. Perhaps the most striking recorded example of deflection caused by rocks in the sea-bed over which a vessel was sailing is that of H.M.S. surveying vessel *Meda*. This ship, while engaged in surveying on the north coast of Australia near Cossack, reported that when three miles off the shore and in eight fathoms of water her compass was steadily deflected 30° for a period of fifteen minutes, during which time she sailed over one mile. The variation marked down for the east coast of Madagascar is 11° W. to 12° W. But the French men-of-war, which are frequently cruising in these waters, find that the variation near the shore at St. Mary's Isle is only 6° or 7° W. The attraction of the north-seeking end of the compass by the magnetic rocks at the bottom is held accountable for the 5° of alteration. Similar results have been recorded of places upon the coasts of New Zealand.* To many sea-going people this will no doubt be a revelation, for it is only very recently that the influence of rocks under the bottom of a ship has been credited with the power of causing needle deviation. What the exact relationship is between vertical magnetic attraction and the horizontal deflection consequent upon it, is at present undetermined. But further researches in the matter will be watched with the keenest interest by the nautical profession as well as the scientific public.

Another alleged cause of compass deviation is fog. A large percentage of the strandings which occur during fogs are ascribed to unknown errors in the compass. A careful perusal of these cases, however, establishes the important fact that no authentic case of fog disturbance has ever been adduced except to account for an apparent mistake in reckoning. Observations taken to test this theory show there is little or no foundation for it. The most sensitive instruments at Kew show no alteration in their directive power during the densest fogs. Staff-Commander Creak, superintendent of compasses at the Admiralty, expresses the opinion that bad steering in all probability accounts for the compass deviation attributed to fog. When a ship is in sight of land, the objects visible on shore form points of reference by which any looseness of steering can be compensated. Should a fog come on, and the same careless hand remain at the wheel, it is possible that now, when the correcting objects on shore are no longer visible, a falling off of the vessel from her course may result in her stranding. It is just possible, also, that in the case of some of the strandings attributed to compass error caused by fog, the real cause of the deviation may be magnetic rocks lying in close proximity to the vessel.

Some of the causes of compass errors would be amusing were they not productive of the most disastrous consequences. Some little time ago a vessel was wrecked in the Channel during thick weather. It transpired, at the inquiry into her loss, that when the master made the observation by which the fatal course was fixed that sent the vessel ashore, the man at the wheel was wearing a magnetic belt. It was consequently assumed that the compass needle was deflected by "Jack's belt," and that when he left the wheel the deflection disappeared, and the compass, having assumed its normal condition, led the ship on to destruction. The metallic ribs of an umbrella thoughtlessly placed near the standard compass by a passenger have been known to produce a deviation of the needle, and consequent erratic steering.

The two accidental causes of error alluded to above point their own moral. Officers and crew, or even passengers, may carry about their persons some hidden source of magnetic force which, if taken near to the steering compass, will undoubtedly influence it, possibly without the error being detected for the time being. It is evident that ships' compasses will have to be jealously guarded from any possible deflection from these hidden influences.

Now that electricity is coming into such general use on board steamships, too much care cannot be taken to procure for the compass absolute immunity from its influence. With a perfect insulation there is no danger; but many cases confirm the opinion that where the installation is carried out on unscientific principles, or where the insulation is imperfect, the compasses may be rendered absolutely dangerous.

Speaking of this phase of the subject, Captain Creak has laid it down as an axiom that the dynamos employed should be placed at least 35 feet from the compasses. On board the *Euphrates* the compass, though 40 feet away, was affected by the polarity of an Edison machine. Both poles of the machine should be at an equal distance from the compass, while the lead and return wires should be placed as near together as possible and carefully insulated. A most interesting example of what may occur with improper installation is evidenced by experiment on H.M.S. *Royalist*. One of the wires from a dynamo was made to pass under the standard compass at a distance of some 13 feet. The return wire was separated from it by some 5 feet. The passage of the electric current along the wire caused a deflection of some 8°, which increased with the strengthening of the current. The compass in this way was transformed into a galvanometer, registering any variation in the strength of the current with the utmost exactness. Vessels whose electric lighting system provides but a single wire lead and utilizes the hull as return, very materially increase the risk they run of having their compasses thrown into error.

In conclusion, it must not be lost sight of that each ship possesses an individual magnetic character of her own, and

* There is a similar area of magnetic deflection in the Adriatic which was surveyed at the request of Father Secchi. It seems probable that such local disturbances are due to the action of hot springs or volcanic vents, which affect rocks containing magnetic oxide of iron or other magnetic matter and cause them to become magnetic radially with respect to the source of heat. In other situations magnetic strata take up the induced magnetism of the earth, and would not sensibly disturb the direction of the compass.—A. C. R.

it is only by a scientific study of this character that her compasses can be guarded against the influence of local magnetic action. As the constituents of this action are to a large extent variable, it behoves the mariner to be ever on the watch for causes which may interfere with the reliability of his "directive index." With the use of iron for shipbuilding, and the introduction of electric lighting on board ships, the necessity for increased watchfulness is considerably augmented. With regard to the external disturbing forces little danger is to be anticipated from magnetic rocks during the day; but at night, shipmasters who love to shave corners would do well to ponder on the instances of the vertical attraction of rocks adduced above.

HARMLESS PARASITES AND UNINVITED COMPANIONS.—II.

By HENRY J. SLACK, F.G.S., F.R.M.S.

AMONGST the microscopic animals that are apt to swarm upon other creatures, perhaps the commonest are members of the vorticella or bell polyp family. They are frequently so numerous as to surround their victims like a cloud, and must be a great nuisance to them. In these cases the assailants must be regarded as parasites, though not of the worst sort, as they do not feed upon their landlords.

When an intestinal worm makes its abode in the liver, brain, or muscle of some mammal, the parasitism is of the worst kind, for it destroys living tissue. In a milder set of instances parasitic invaders live like Jonah in the stomachs of their hosts, and nourish themselves upon some of the food the latter collect. This is robbing a neighbour's pantry of part of its contents; but if plenty is left for his own consumption, no great harm is done. The *Holothurida*, or sea slugs, that supply microscopists with beautiful objects in the shape of the calcareous wheels, anchors, and curiously perforated plates with which their integuments are beset, also furnish many instances of parasitism. One species affords board and lodging in its stomach to a small eel-like fish (*Donzella*); while others that collect a very liberal commissariat are visited as boarders by prawns and pea-crabs. Beneden tells us that his friend Semper found some of these creatures in the Philippines who were not bad imitations of an hotel furnished with a *table-d'hôte*.

Sea anemones and jelly-fish frequently act as hotel keepers, and Dr. Collingwood found in the China seas a monster of the former kind ten feet in diameter, sheltering in its interior some lively little fish. This is the more curious as these animals are well armed with poison threads, or flexible darts, which they project with considerable penetrating power; and Gosse mentions an instance of a little fish that died in a few minutes in great agony through a momentary contact of its lips with one of these weapons. For full and very interesting particulars of these organs the reader is referred to Gosse's *British Sea Anemones*; but those who visit the seaside with microscopes may easily see some of them by snipping off a little piece of an anemone's tentacle, and viewing it under compression with a high power. One form of these weapons is shown in the sketch copied from Gosse (Fig. 1). The vesicle he calls a *cnida*, and the thread coiled in it an *ecthorea*. This the animal was flinging out with lightning velocity and great force.

Whether an anemone that plays the host to little fishes derives any benefit or pleasure from their company we do not know, but if it found them objectionable lodgers it would turn them out. It is often puzzling or impossible to comprehend the human motives that impel to extraordinary actions, and still more so is it to imagine the *why* of many doings of the lower animals. Why, for example, does one species of hermit crab, that has taken the shell of some gasteropod for its dwelling, encourage the cloak anemone (*Adamsia palliata*) to fix itself on the lip of its abode? Lieut.-Col. Stuart-Wortley tells us that the crab offers its companion a share of its food captures, and assists the anemone to move with it when it finds its home too small and takes possession of a larger shell. No species of hermit crab except *Pagurus Prideauxii* forms this curious connection, and the most probable explanation of the partnership is that suggested by Dr. Landsborough, cited by Gosse. He says, in all likelihood they in various ways aid each other. The hermit has strong claws, and while he is feasting on the prey he has caught, many spare crumbs may fall to the share of his gentle-looking companion. But soft and gentle-looking as the anemone may be, she has a hundred hands, and woe be to the wandering wight who comes within reach of one of them, for all the other hands are instantly brought to its aid, and the hermit may soon find that he is more than compensated for the crumbs that fall from his own booty.

Collectors of pond objects often find the fresh-water polyp, and frequently discover it in association with an infusorium, the *Trichodina pediculus*, which can attach itself to its host by a sucker, or run freely over it by means of cilia that do the work of legs. The currents it produces by its ciliary organs must be useful to the polyp, and it is said to act as scavenger and to remove waste matter from its friend's skin. Another infusoria, *Kerona polyporum*, also settles on the polyp, and Kent says that "where the two abound, it may be not unfrequently observed that the *Trichodinæ* mount upon the backs of their companions, and thus utilise them as a man might a horse, for the enjoyment of locomotion, without having to participate in the labour of its production." Like the anemone and the jelly-fish, the polyp has poison threads, and could destroy its visitors if it objected to their presence.

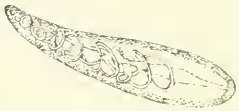


FIG. 1.—CHAMBERED CNIDÆ.

A great many other instances might be given of animals boarding together in friendly harmony or actual co-operation. Amongst the crustaceans such partnerships are numerous, and a tiny pea-crab that makes its abode in mussel-shells is evidently welcome to its shelter.

The ancients, Beneden says, noticing the mussel's blindness, thought the crab's sharp eyes enabled it to see by deputy; but a more probable solution of the question is that the crab is a good food-catcher, and the mussel enjoys part of the spoils.

Fishes are visited by numerous animal and vegetable colonists, some harmless and others destructive. In all quarters we find both fellow-boarders and parasites, and it is to be remarked that while the latter have always attracted attention, the former, with few exceptions, have only recently been studied as they deserve.

Fig. 1, after Gosse, represents a very elaborate but "most generally distributed form of *Chambered Cnidæ*"; the vesicles are about ·004 inch long, and in greatest diameter ·0005 inch. Inside the vesicle is a slender, lozenge-shaped chamber, from which proceeds a very long convoluted tube, often from twenty to forty times the length of the *Cnida*. Gosse describes the protrusion of the poison-thread as beginning by a nipple-shaped wart from the anterior extremity, and often proceeding slowly till it

has attained a length of about twice its own diameter, and then darting forth with lightning rapidity. At this instant he said he had in many instances "heard a distinct crack." The writer believes this to have been a delusion. It often occurs in watching the jaws of a large Brachion rotifer, and similar apparatus. A movement which if performed by a mechanism large enough to affect our hearing would make a crack or snap-like noise, is readily imagined to do so when the eye watches a magnified image under the microscope. There are many much simpler poison-threads

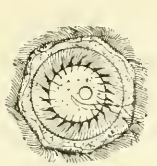
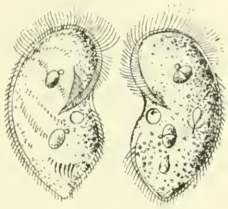


Fig. 2.
Trichodina pediculus.



Figs. 3 and 4.
Kerona polyporum.

than that in the figure. Those in the polyp are far less elaborate but instantly effectual.

Fig. 2 represents *Trichodina pediculus* seen from above in full face. Besides delicate cilia, it has a wreath of horny *denticles*, or little teeth. A side view, when it runs about, shows it as a squat cylinder. Its skin is very flexible, and it can assume various shapes, disc-like, conical, hour-glass, &c.

Figs. 3 and 4, *Kerona polyporum*, ventral and dorsal aspects. It belongs to the *Hypotricha*, which have × 200 thin locomotive cilia on the ventral surface only. It has not, like the *Trichodina*, the power of changing its shape. It is a greedy animal, eating both animals and vegetables, but it abstains from feeding upon its host the polyp.

THE FACE OF THE SKY FOR SEPTEMBER.

By Herbert Sadler, F.R.A.S.

The abnormal paucity of sun-spots still continues. Conveniently observable minima of Algol occur at 6h. 12m. p.m. on the 1st; 11h. 4m. p.m. on the 18th; and 7h. 52m. p.m. on the 21st. Mercury is an evening star during the first half of the month; but is very badly situated for observation, owing to his proximity to the sun. As the interval between the setting of the sun and planet does not exceed half-an-hour throughout the month, any details would be useless. He is at his greatest eastern elongation (27°) on the 3rd, and is in inferior conjunction on the 29th.

Venus is an evening star, but is not well situated for observation owing to her southern declination. She sets on the 1st at 7h. 59m. p.m., 1h. 13m. after the sun, with a southern declination of $10\frac{1}{2}$°, and an apparent diameter of $19\frac{3}{4}$″. On the 30th she sets at 6h. 11m. p.m., 1h. 5m. after the sun, with a southern declination of 22° 20′, and an apparent diameter of $26\frac{1}{2}$″. About the middle of September she appears as a moon about her last quarter; and is at her greatest eastern elongation ($46\frac{1}{2}$°) on the 24th. During the month she passes from Virgo into Libra, but without approaching any conspicuous naked-eye star. Mars is an evening star, and our remarks in last month's "Face of the Sky," as to his telescopic aspect, will, unfortunately for the amateur, rather gain than lose in strength. The planet sets on the 1st at 9h. 5m. p.m., with a southern declination of $25\frac{3}{4}$°, and an apparent diameter of 11·1″. On the 30th he sets at 9h. 17m. p.m., with a southern declination of 25° 55′, and an apparent diameter of $9\frac{1}{4}$″. At the latter date his brightness is only about one quarter of what it was at opposition, and about $\frac{85}{100}$ of the disc will be hidden from view. Mars is in quadrature with the sun on the 21st, and passes during the month from Ophiuchus into Sagittarius, but without approaching any bright star very closely.

Jupiter is an evening star, rising on the 1st at 5h. 26m. p.m., with a southern declination of 20° 10′, and an apparent equatorial diameter of $46\frac{1}{2}$″. On the 30th he rises at 3h. 28m. p.m., with a southern declination of 20° 26′, and an apparent equatorial diameter of 43·0″. The following phenomena of the satellites occur while the planet is more than 8° above, and the sun 8° below, the horizon. A transit ingress of the first satellite at 0h. 29m. a.m. on the 2nd, an occultation disappearance of the same satellite at 9h. 49m. p.m., and a transit ingress of the third satellite at 11h. 52m. p.m. A transit ingress of the shadow of the first satellite at 7h. 46m. p.m. on the 3rd; a transit egress of the satellite itself at 9h. 16m. p.m., and a transit egress of its shadow at 10h. 6m. p.m. An occultation disappearance of the second satellite at 9h. 10m. p.m. on the 5th. An eclipse reappearance of the third satellite at 8h. 49m. 49s. p.m. on the 6th. A transit egress of the shadow of the second satellite at 8h. 58m. p.m. on the 7th. An occultation disappearance of the first satellite at 11h. 36m. p.m. on the 9th. A transit ingress of the first satellite at 8h. 44m. p.m. on the 10th, a transit ingress of its shadow at 9h. 41m. p.m.; a transit egress of the satellite at 11h. 4m. p.m., and of its shadow one minute after midnight. An eclipse reappearance of the first satellite at 9h. 19m. 40s. p.m. on the 11th. An occultation disappearance of the second satellite at 11h. 31m. p.m. on the 12th. An occultation reappearance of the third satellite at 8h. 51m. p.m. on the 13th, and an eclipse disappearance of the same satellite at 9h. 18m. 41s. p.m. A transit ingress of the shadow of the second satellite at 8h. 40m. p.m. on the 14th; a transit egress of the satellite itself at 9h. 32m. p.m., and of its shadow at 11h. 35m. p.m. A transit ingress of the shadow of the fourth satellite at 7h. 25m. p.m. on the 16th (the shadow crosses the central meridian at 9h. 50m. p.m.). A transit ingress of the first satellite at 10h. 32m. p.m. on the 17th. An occultation disappearance of the first satellite at 7h. 52m. p.m. on the 18th, and an eclipse reappearance of the first satellite at 11h. 14m. 57s. p.m. A transit egress of the first satellite at 7h. 20m. p.m. on the 19th, and of its shadow at 8h. 25m p.m. An occultation disappearance of the third satellite at 8h. 47m. p.m. on the 20th. A transit ingress of the second satellite at 9h. 2m. p.m. on the 21st, and of its shadow at 11h. 17m. p.m. An eclipse reappearance of the second satellite at 8h. 18m. 11s. p.m. on the 23rd. An egress of the shadow of the third satellite at 6h. 53m. p.m. on the 24th, and an occultation reappearance of the fourth satellite at 9h. 32m. p.m. An occultation disappearance of the first satellite at 9h. 42m. p.m. on the 25th. A transit ingress of the first satellite at 6h. 50m. p.m. on the 26th, a transit ingress of its shadow at 8h. 0m. p.m.; a transit egress of the satellite itself at 9h. 10m. p.m., and of its shadow at 10h. 21m. p.m. An eclipse reappearance of the first satellite at 7h. 39m. 4s. on the 27th. Jupiter describes a very short retrograde path in Capricornus during the month, but does not approach any naked-eye star. He is stationary on the 28th.

Saturn and Uranus are practically invisible. Neptune is an evening star, rising on the 1st at 9h. 43m. p.m.,

with a northern declination of 19° 51′, and an apparent diameter of $2\frac{1}{2}''$, the planet appearing as a small 8th magnitude star. On the 30th he rises at 7h. 50m. P.M., with a northern declination of 19° 49′. He describes an excessively short retrograde arc to the N.N.W. of ϵ Tauri during the month. A map of his path till the end of the present year is given in the *English Mechanic* for November 15, 1889.

The following places, for every fifth day in September, of the comet discovered by Mr. Denning on July 23rd, are taken from Herr Berberich's ephemeris. They are for midnight, Berlin mean time. The brightness at the time of discovery is taken as unity. The comet will pass its perihelion on September 24th, at a distance from the sun of $123\frac{1}{4}$ millions of miles, and from the earth of $138\frac{1}{2}$ millions of miles.

		h.	m.	s.	°	′	Brightness.
September	1	15	37	52	+25	14·4	2·21
,,	5	15	41	24	+19	21·5	2·18
,,	10	15	45	53	+12	22·6	2·08
,,	15	15	50	26	+ 5	54·5	1·95
,,	20	15	55	4	− 0	0·2	1·80
,,	25	15	59	46	− 5	21·8	1·60
,,	30	16	4	32	− 10	12·3	1·45

The comet thus plunges from Corona Borealis through Serpens and part of Libra into Scorpio. There are no well-marked showers of shooting-stars in September.

The moon enters her last quarter at 3h. 29m. A.M. on the 6th, is new at 7h. 53m. A.M. on the 14th, enters her first quarter at 10h. 5m. P.M. on the 21st, and is full (Harvest Moon) at 1h. 0m. P.M. on the 28th. The 6th magnitude star 64 Ceti will disappear at 10h. 40m. P.M. on the 2nd at an angle of 138° from the vertex, and reappear at 11h. 12m. P.M. at an angle of 202° from the vertex, and the $4\frac{1}{2}$ magnitude star ξ^1 Ceti will make a near approach to the lunar limb at 11h. 53m. P.M. at an angle of 175° from the vertex. On the 3rd at 6h. 32m. A.M. (one hour and eighteen minutes after sunrise) the $7\frac{1}{2}$ magnitude star B.A.C. 741 will make a near approach to the lunar limb at an angle of 58° from the vertex. The 6th magnitude star B.A.C. 1206 will disappear at 9h. 32m. P.M. on the 4th at an angle of 49° from the vertex, and reappear at 10h. 20m. P.M. at an angle of 277° from the vertex. The 6th magnitude star B.A.C. 1240 will disappear at 1h. 14m. A.M. on the 5th, at an angle of 75° from the vertex, and reappear at 2h. 22m. A.M. at an angle of 262°. The 6th magnitude star B.A.C. 1801 will disappear at 11h. 55m. P.M. on the 6th, at an angle of 99° from the vertex, and reappear at 0h. 42m. A.M. on the 7th at an angle of 208° from the vertex. The 6th magnitude star 24 Ophiuchi will disappear at 7h. 56m. P.M. on the 20th at an angle of 120° from the vertex, and reappear at 9h. 3m. P.M. at an angle of 285° from the vertex, the moon having set at Greenwich 15 minutes previously. At 7h. 57m. P.M. on the 21st the $6\frac{1}{2}$ magnitude star 63 Ophiuchi will make a near approach at an angle of 197° from the vertex. At 11h. 33m. P.M. on the 24th the $5\frac{1}{2}$ magnitude star χ Capricorni will make a near approach at an angle of 226° from the vertex. The $4\frac{1}{2}$ magnitude star 30 Piscium will disappear at 10h. 36m. P.M. on the 27th at an angle of 123° from the vertex, and reappear at 11h. 45m. P.M. at an angle of 295°. The 5th magnitude star 33 Piscium will disappear at 0h. 32m. A.M. on the 28th at an angle of 100° from the vertex, and reappear at 1h. 28m. P.M. at an angle of 356°. On the 29th the 6th magnitude star 26 Ceti, which has a lilac-coloured 9th magnitude companion at $16\frac{1}{2}''$ distance, will disappear at 3h. 24m. A.M. at an angle of 146° from the vertex, and reappear at 4h. 28m. A.M. at an angle of 338° from the vertex; at 5h. 42m. A.M. the $6\frac{1}{2}$ magnitude star 29 Ceti will disappear at an angle of 169° from the vertex, and reappear at 6h. 35m. A.M., 36 minutes after sunrise, at an angle of 279°; while at 7h. 18m. P.M. the $4\frac{1}{2}$ magnitude star ν Piscium will make a near approach to the lunar limb at an angle of 167° from the vertex.

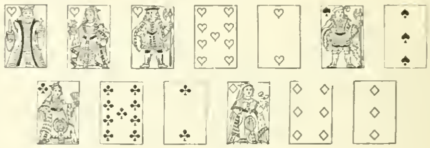
Whist Column.

By W. MONTAGU GATTIE.

DECLINING TO DRAW THE LOSING TRUMP.

WE are indebted to Mr. H. W. Trenchard for the following hand, which occurred recently in actual play, and furnishes an instructive illustration of the good policy, under certain circumstances, of not drawing the losing trump.

HAND No. 13.

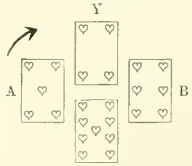


Z's Hand.

Score—2 all. Z turns up the Nine of Hearts.

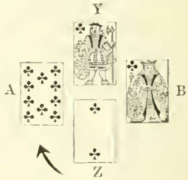
NOTE.—A and B are partners against Y and Z. A has the first lead; Z is the dealer. The card of the leader to each trick is indicated by an arrow.

TRICK 1.



Tricks—AB, 0; YZ. 1.

TRICK 2.

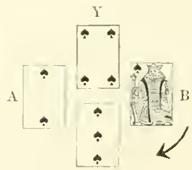


Tricks—AB, 1; YZ, 1.

NOTES.—*Trick* 1.—The three of hearts is marked in A's hand, and therefore he holds five trumps.

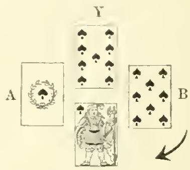
Trick 2.—Z treats his best short suit as a long one, and leads the lowest. We should have preferred to lead the knave of spades.

TRICK 3.



Tricks—AB, 2; YZ, 1.

TRICK 4.

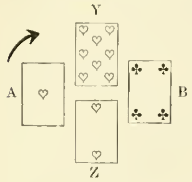


Tricks—AB, 3; YZ. 1.

NOTES.—*Trick* 3.—B is clearly void of trumps.

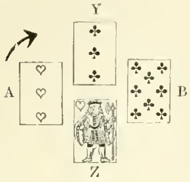
Trick 4.—B has continued with the fourth-best spade, and must hold queen, ten; therefore Y can have no more spades, and the other five are with B or A.

Trick 5.



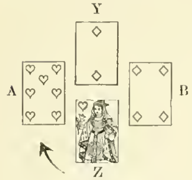
Tricks—AB, 4; YZ, 1.

Trick 6.



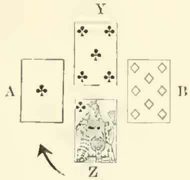
Tricks—AB, 4; YZ, 2.

Trick 7.



Tricks—AB, 4; YZ, 3.

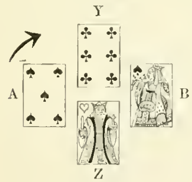
Trick 8.



Tricks—AB, 5; YZ, 3.

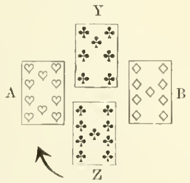
Note.—*Trick* 8.—The trick of the hand. The ace of clubs is against Z (see Trick 2); and, if he draws the losing trump before clearing the clubs, there will be nothing to prevent AB from making their spades, save in the unlikely event of A's holding the ace of clubs and B's holding all the spades. Of course, if B holds a card of re-entry in diamonds, or if A holds a winning diamond and two spades, the game cannot be saved by any play.

Trick 9.



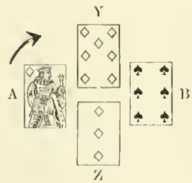
Tricks—AB, 5; YZ, 4.

Trick 10.



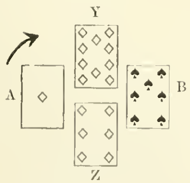
Tricks—AB, 6; YZ, 4.

Trick 11.



Tricks—AB, 7; YZ, 4.

Trick 12.



Tricks—AB, 8; YZ, 4.

Trick 13.—A leads the five of diamonds, which Z wins with the queen.

AB score two by cards, and

YZ save the game and score two by honours.

A's Hand	B's Hand.
H.—Ace, 10, 7, 5, 3.	H.—6.
S.—Ace, 5, 2.	S.—Kg, Qn, 10, 8, 7, 6.
D.—Ace, Kg, 5.	D.—9, 8, 4.
C.—Ace, 10.	C.—Kg, 8, 4.

Y's Hand.	Z's Hand.
H.—8, 4.	H.—Kg, Qn, Kn, 9, 2.
S.—9, 4.	S.—Kn, 3.
D.—Kn, 10, 7, 2.	D.—Qn, 6, 3.
C.—Kn, 7, 6, 5, 3.	C.—Qn, 9, 2.

Remarks.—It is worth noticing that players who adopt the "plain-suit echo" would infer from A's deuce of spades at Trick 3 that he held not more than three of the suit originally. This information would enable Z, after Trick 4, to place four spades at least in B's hand.

At Trick 4 A reads the remaining spades in his partner's hand, and, having command of the adverse clubs, the two best diamonds, and a card of his partner's suit, he rightly draws two rounds of trumps at Tricks 5 and 6, and may very reasonably have expected to make three by cards even if the honours should prove to be (as was the fact) all in one hand. If Z had opened the diamonds at Trick 8, A after winning with king would have secured the game by leading the losing trump; but A dare not follow this course after parting with his ace of clubs, for if the long clubs should be in one hand he may even lose the game.

Chess Column.

By I. Gunsberg.

We publish below two more games of the recently-played match Blackburne *v.* Lee won by the former player, the final score being Blackburne won 5, Lee won 2, and 7 draws. The ninth game, although weakly played by White, contains some instructive as well as entertaining features. If closely followed, step by step, it may be noticed that while White kept standing still through losing time, Black's effective strength and advantage in position seemed to grow correspondingly with every move. Then, making good use of his superior development, he pushed on his attack at the proper moment, and this resulted in material gain by a very fine combination, of which even Black may be proud, and he finished off the game both elegantly and expeditiously.

Game ten is no less pleasing than its predecessor. Again Blackburne constructs his game in masterly manner, defending himself against the effort of his opponent to take advantage, according to stereotyped rules, of the open file on the QKt line; but at the same time, thinking also of attacking possibilities, he places all his pieces very efficiently, and then suddenly develops the attack on his unsuspecting opponent, and by a very pretty manœuvre on the thirtieth move, he soon gets an overwhelming advantage.

It will be recollected that Lee won both his games from Blackburne and Burn in the Bradford Tournament. This fact, in conjunction with the play in this match, brings into relief very strongly the difference between tournament play and match play. In the former case a strong player playing for a high prize, when meeting an inferior opponent, with whose play he is perhaps not very familiar, tries very hard not to draw against him. Very often, however, the only thing which such players know how to do is to play for a draw. A little nervousness when meeting such a player, or the dread not to lose half a point, will often cause the stronger player to lose. But in a match it is quite different. Then, after two or three games, the stronger player will, so to speak, completely take the measure of his opponent, and if he is in a position not to mind the draw, the weaker player will have no chance whatever.

Game No. 9.

French Defence.

White. Blackburne.	Black. Lee.	White. Blackburne.	Black. Lee.
1. P to K4	P to K3	14. B × Kt	KtP × B
2. P to Q4	P to Q4	15. Kt to K2 (*e*)	R to QKtsq
3. QKt to B3	KKt to B3	16. Castles (KR)	Castles (KR)
4. B to KKt5 (*a*)	B to K2	17. R to B2 (*f*)	B to Q2
5. P to K5	KKt to Q2	18. P × P	Q × P
6. B × B	Q × B	19. QKt to Q4	R to Kt2
7. Q to Q2 (*b*)	P to QR3 (c)	20. Kt × Kt	B × Kt
8. QKt to K2(*d*)	P to QB4	21. Kt to Q4	B to Q2
9. P to KB4	QKt to B3	22. R to Ksq	KR Ktsq
10. P to B3	P to B4	23. Q to Bsq	P to QR4
11. Kt to B3	P to QKt4	24. QR to K2	P to R5
12. P to KR3	Kt to Kt3	25. P to R3	K to Rsq
13. Kt to Bsq	Kt to B5	(50 min.)	(55 min.)

WHITE. Blackburne.	BLACK. Lee.	WHITE. Blackburne.	BLACK. Lee.
26. P to KKt4 (*g*)	P to Kt3 (*h*)	32. Kt × BP (*n*)	Q to Bsq
27. Q to K3 (*i*)	Q to K2	33. Kt to Q6	R to Ktsq
28. R to Kt2	R to KKtsq (*k*)	34. Q to R7	R to Ksq (*p*)
29. P × P	KtP × P (*l*)	35. Q × B	R to K2
30. R × R (ch)	K × R	36. Q to B8	Resigns.
31. R to Kt 2(ch)	K to Rsq (*m*)	(1 hour 17 min.)	(1 hour 37 min.)

NOTES.

(*a*) This move still holds the field, in spite of 4. P to K5, which took the popular fancy for a time after Steinitz's celebrated Habana game.

(*b*) This used to be the way in which the German players usually met Blackburn's French Defence.

(*c*) Black may castle here; P to R3 is not essentially necessary at this point.

(*d*) The proper square to place this Knight is K3 via Qsq.

(*e*) White seeks to plant his Knight at Q4.

(*f*) White posts his forces in advantageous positions. The Rook on B2 anticipates an attacking design on the QKtP, and is also available for the support of an attack on the King's side should P to KKt4 become feasible.

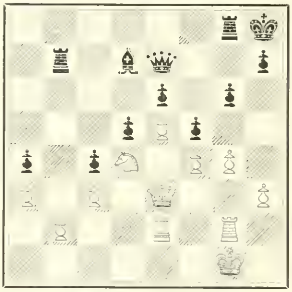
(*g*) A promising venture. White's position is admirably contrived, as he has nothing to fear from Black.

(*h*) P×P 27. P×P, P to Kt3 would also have left White a preponderating advantage.

(*i*) Threatening Kt×BP, and thereby bringing his Queen into better play.

(*k*) R to KBsq would have been met by White with 29. P×P, KtP×P 30. R to Kt5, R (Kt2) to Ktsq. 31. R(K2) to Kt2, R to Ktsq, Kt×BP all the same.

BLACK.—LEE.



WHITE.—BLACKBURNE.

Position after Black's 28th move, R to K Ktsq.

(*l*) KP×P would be followed by P to K6 and Q to K5 (ch).

(*m*) With K to Bsq Black might have held out longer.

(*n*) As effective as it is pretty. If P×Kt 33. P to K6, then the check on Q4 kills Black.

(*p*) If R to Qsq 35. Q to B7, threatening Q×R.

GAME NO. 10.

ZUKERTORT'S OPENING.

WHITE. Lee.	BLACK. Blackburne.	WHITE. Lee.	BLACK. Blackburne.
1. KKt to B3	P to Q4	16. Kt to KB3	Castles
2. P to Q4	B to Kt5 (*a*)	17. Kt to B5 (*i*)	B×Kt
3. Kt to K5 (*b*)	B to B4	18. P×B	P to K4
4. P to QB4 (c)	P to KB3	19. Q to R4	B to Ksq (*k*)
5. Kt to KB3	P to B3	20. R to Bsq	P to K5
6. P×P	P×P	21. Kt to Ktsq (*l*)	P to B4 (*m*)
7. Kt to B3	P to K3	22. B to K2	Q to K3
8 Q to Kt3	Q to Q2	23. P to Kt4 (*n*)	Kt to K4
9. Kt to KR4 (*d*)	B to KKt5	24. Q to Qsq	P×P
10. P to K3	Kt to B3	25. P×P	Q×P (o)
11. P to QR3 (*e*)	R to Bsq	26. B to QB3	Q to Kt7
12. B to Q2	B to Q3	27. B×Kt	Q×R
13. Kt to R4 (*f*)	KKt to K2	28 K to Bsq	B to Q2
14. P to R3 (*g*)	B to R4	29. P to B3	B to R6 (ch)
15. P to Kt4 (*h*)	B to KB2	Resigns (2 hours).	
(36 min.)	(42 min.)		

NOTES.

(*a*) The move commits Black to an attack on the King's side, because it leaves his Queen's wing weak for the end game. Independent of this question, I think Black should not play B to KKt5 before White has moved his KP.

(*b*) Experience has not yet confirmed this move sufficiently. In advancing thus early, the Knight is exposed to wind and weather.

(*c*) P to K3 followed by B to Q3 might be employed to better advantage than the test move.

(*d*) White does not get much comfort out of this move. This is the second time this Knight has attacked the Bishop on a square from which he will have to retire.

(*e*) White does not seem to have any settled plan of action, and is losing ground in consequence.

(*f*) This move adds to the list of wasted opportunities for making developing moves.

(*g*) All this helps Black, whose Bishop is better posted on B2 than Kt5.

(*h*) This move adds additional weakness to White's game.

(*i*) It matters little what White does, as his game is hopelessly compromised, but this move facilitates Black's advance in the centre.

(*k*) Black evidently intends to advance on the KB file and B to Ksq. While preparing for this, also threatens other contingent dangers, such as Kt to Q5, &c., which, under circumstances, might become dangerous.

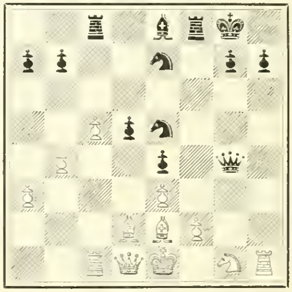
(*l*) If I had to illustrate the meaning and importance of losing time I should chose the moves of the Knight in this game as a good example. Out of 21 moves made, White has made 6 ineffective moves with this Knight, and has now again reached his starting-point, namely, 1. Kt to KB3, 2. Kt to K5, 3. Kt to KB3, 4. Kt to KR4, 5. Kt to KB3, 6. Kt to Ktsq.

(*m*) Black increases his advantage with every move.

(*n*) Even if White had guessed the beautiful combination which Black was working out, he could do little else except Q to Qsq.

(*o*) A surprisingly fine conception. Of course if B×Q, mate in two follows. Diagram appended.

BLACK.—BLACKBURNE.



WHITE.—LEE.

Position after Black's 25th move, Q × P.

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CONTENTS.

GIANT LAND REPTILES.

By R. Lydekker, B.A.Cantab.

THE traveller from London to Hastings, by way of the South-Eastern Railway, on leaving the tall chalk hills of the North Downs, some short distance to the north of Sevenoaks, enters suddenly on a more open district, known as the Weald of Kent and Sussex. This district presents many remarkable and peculiar features, one of the most striking being the great prevalence of oak-trees in those parts having a clayey soil; and the traveller will not fail to notice that, in place of the chalk which he has just left, all the rocks of the district consist of alternations of beds of clay, sands, and sandstone. These peculiarities in the structure of the rocks continue the whole way to Hastings; and the tall cliffs of sandstone, on one of which are perched the ruins of the ancient castle, rising to the eastward of that town, and forming the most prominent features in the landscape of the neighbourhood, are too well known to require further mention. The whole of this extensive series of rocks, which attains a vertical thickness of many hundred feet, and has been much worn away by atmospheric action, and also thrown into a series of folds, is considerably older than the chalk, from which it is separated by the beds known as the Upper Greensand, Gault, and Lower Greensand, and is collectively known as the Wealden series, or formation. Instead of having been formed, like the overlying chalk and other deposits, at the bottom of an ancient sea, the whole of the Wealden beds are of purely fresh-water origin—a circumstance abundantly proved by the fossils found in the beds themselves, which comprise fresh-water shells, and the remains of land plants and land animals, to the total exclusion of all marine organisms. It is, indeed, probable that the area of the Wealden strata, which originally extended from Kent to the Isle of Wight, once formed the delta of a mighty river, flowing into the North Sea, and draining a very considerable portion of Northern Europe, during that period of the Secondary epoch of the geological scale immediately preceding the one in which the greensand and chalk were deposited.

Apart from its many other points of interest to the geologist, as well as those which it presents to the botanist and the archæologist, the Wealden area has an especial and unique claim on the attention of the palæontologist. It was, indeed, mainly from the huge fossil bones obtained during the earlier decades of the present century from these deposits, by the late Dr. Gideon A. Mantell, of Lewes (whose perseverance in the collection and description of these remains during the hard-earned leisure of a laborious medical practice cannot be too highly praised), that our first definite knowledge was acquired of that wonderful group of extinct land reptiles forming the subject of the present article. These creatures, for which Sir Richard Owen has proposed the name of Dinosaurs (Gr. *deinos*, terrible, and *sauros*, a lizard), were certainly worthy of their name, for it is impossible to conceive more appalling monsters than those which we propose to briefly notice.

Fig. 1.—Outer Side of the Crown of a Tooth of the Iguanodon.

The labours of Dr. Mantell were mainly devoted to the Wealden rocks near the village of Cuckfield, in the neighbourhood of Brighton, where this enthusiastic worker obtained a great number of bones of teeth, which are now preserved as some of the most valued treasures of the British Natural History Museum. These specimens, imperfect though many of them were, enabled their discoverer to affirm that the old delta of the Weald was once inhabited by several kinds of extinct reptiles, all of which were totally unlike any existing forms, and some of which vastly exceeded in size any land animals now living upon the earth. By patient research Mantell was enabled to arrive at a fair approximation of the general form of the skeleton of some of these strange and uncouth inhabitants of a former world; but from the fragmentary condition of the remains of other species, and the extreme peculiarity of their structure (as now known by entire specimens), he never even dreamt what weird creatures he had been the means of first bringing to the notice of the scientific world of his time.

One of the first, and at the same time one of the strangest, of these Giant Reptiles discovered by Mantell, was first definitely determined from the evidence of the detached teeth, which are of not uncommon occurrence in some of the Wealden beds, and one of which is shown of the natural size in the accompanying woodcut (Fig. 1). These teeth have peculiarly flattened crowns, with well-marked flutings on the outer surface, and with serrated lateral edges. In many of them the tops of the crowns are found to be worn quite flat by mutual abrasion; and it then became evident that these teeth indicated a reptile of herbivorous habits, which was also of gigantic size. From the somewhat distant resemblance presented by the

teeth to the very much smaller ones of an American lizard known as the Iguana, Dr. Mantell proposed to call the huge Wealden monster the Iguana-toothed Reptile, or, technically, the Iguanodon. In the course of time numerous more or less nearly entire bones of this creature were obtained, when it was found that the thigh-bone of some specimens considerably exceeded a yard in length. This at once gave a clue to the enormous bulk of these reptiles, since the corresponding bone of the largest existing crocodile scarcely exceeds a foot in length. Finally, it was estimated that the Iguanodon was a creature about 30 feet in length, with a body as large as that of an elephant, and that it walked on all four feet like a crocodile. Accordingly, many years ago a restoration of the Iguanodon was set up in the gardens of the Crystal Palace, when the creature was modelled somewhat after the fashion of a large-bodied and short-tailed crocodile. After Mantell's death other earnest investigators occupied themselves with the structure of the skeleton of this creature, and finally arrived at the unexpected conclusion that in many respects—more especially as regards the structure of the haunch-bones and limbs—the skeleton made a very curious approximation to that of birds, and was quite unlike that of living reptiles.

As we all know, all things come to those who wait, and the above conclusions were triumphantly supported by the discovery, some few years ago in the Wealden deposits of Belgium, of a number of nearly perfect, although much crushed, skeletons of the Iguanodon. These wonderful discoveries enabled the Belgian naturalists to mount two entire skeletons in the Brussels Museum, in the courtyard of which they now stand as the most marvellous restorations of extinct animals of the Secondary epoch yet known in Europe. Fig. 2 gives a greatly reduced representation of the larger of these two skeletons, of which the total length is about 33 feet. It will be seen from this figure that the creature habitually walked on its hind legs, doubtless partly supported by its powerful tail, in a bird-like attitude. The fore limbs were considerably shorter than the hind ones; and the hands were extremely powerful, and probably served to assist the creature in bringing to its mouth the leaves and fruits upon which we may assume it subsisted. There was a long series of teeth, similar to the one represented in Fig. 1, on the sides of both jaws; but the muzzle was quite toothless, and may perhaps have been sheathed in horn, like the beak of turtles. The extreme shortness of the fore limbs is of itself sufficient to indicate that the Iguanodons really walked on their hind legs like birds; but if we require further evidence on this point it is ready to our hand. Thus in the Wealden sandstones of Hastings there have been found numerous series of impressions of huge three-toed hind feet, which correspond exactly in size with the three-toed feet of the Iguanodon; and, since there are no impressions of the smaller fore feet among these tracks, the bipedal gait of the Iguanodon is again proved from an independent line of evidence. The three toes of the Iguanodon, it may be observed, were terminated by broad and flattened bones more like hoofs than claws, thus again indicating the herbivorous nature of these reptiles.

The description of the details in which the skeleton of the Iguanodon approximates to that of birds would involve too many abstruse anatomical points to be given in these pages. It may be observed, however, that all the bones of the limbs were hollow, as in birds, while those of all living reptiles are solid. Then the two long and rod-like bones descending from the haunches behind the thigh-bone are essentially bird-like in form and position, and differ totally from the corresponding bones of crocodiles and lizards. Again, the reduction of the number of hind toes to three, and the close relationship of the upper bones of the ankle to those of the leg are strong points of resemblance to birds. It is true, indeed, that in birds the three parallel long bones of the foot found immediately below the ankle in the Iguanodon are fused into a single bone, while the ankle-bones are respectively united with the latter and the bones of the leg; but in a fossil reptile from the chalk of the United States, which may be regarded as a distant cousin of our Iguanodon, the arrangement of these bones is so like that obtaining in birds that the difference is merely one of the degree to which specialisation (as naturalists call these peculiar modifications from the ordinary type) has been carried.

Indeed, to those who believe in the evolution of organized nature (and there are very few competent to express an opinion on the subject who do not hold this belief), it now appears to be quite evident that birds have originally

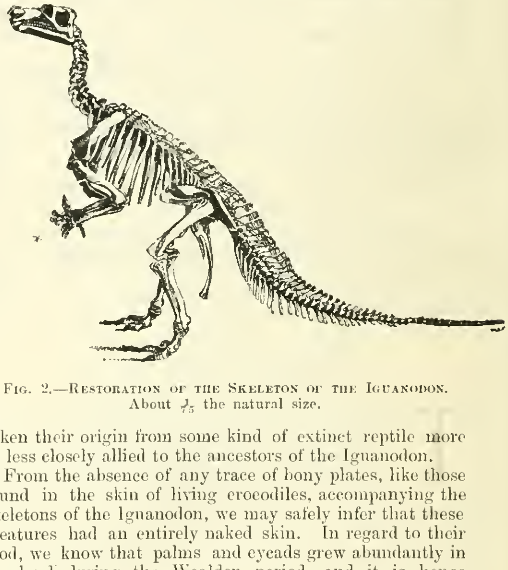


Fig. 2.—Restoration of the Skeleton of the Iguanodon. About $\frac{1}{75}$ the natural size.

taken their origin from some kind of extinct reptile more or less closely allied to the ancestors of the Iguanodon.

From the absence of any trace of bony plates, like those found in the skin of living crocodiles, accompanying the skeletons of the Iguanodon, we may safely infer that these creatures had an entirely naked skin. In regard to their food, we know that palms and cycads grew abundantly in England during the Wealden period, and it is hence highly probable that the fruits of these plants formed a considerable part of the nutriment of these ancient reptiles.

The sight of a herd of these giant Iguanodons, many of which stood over 20 feet in height, stalking on their hind limbs among the old Wealden forests and overtopping many of its trees, must have been a spectacle in comparison to which a drove of elephants in an Indian jungle would be scarcely worth a moment's attention.

A totally different type of Giant Land Reptile from the Sussex Wealden was first indicated to Mantell by a huge bone of the upper arm, or humerus as it is anatomically termed. This stupendous bone, which is now in the British Museum, has a length of upwards of fifty-four inches; it approximates in form to the corresponding bone of the crocodiles, being solid throughout, and is thus totally different from the very much smaller arm-bone of the Iguanodon. As being the largest form with which he was acquainted, Mantell proposed to call the reptile represented by this bone the Pelorosaur, from the Greek *peloros*,

vast, and *sauros*, a lizard. For a long period little or nothing more was known of the structure of this huge creature, but at length specimens were obtained from the Wealden of the Isle of Wight which indicated the nature of its teeth and various parts of its skeleton; while valuable information was also afforded by specimens obtained from the Kimeridge and Oxford clays, which underlie the Wealden beds. It is true, indeed, that the specimens from the Isle of Wight have been described under a different name from those from Sussex, but they differ only in minute points of detail. The tooth shown in woodcut 3 is that of the Isle of Wight reptile, to which the name of Hoplosaur (armed lizard) has been applied. It will be seen that this type of tooth is quite different from that of the Iguanodon, the outer surface of the crown being convex, without flutings, and with smooth edges; while the inner surface is concave, and spoon-like. Specimens of similar teeth from the Sussex Wealden, which evidently belong to the Pelorosaur, are much larger than the figured tooth. The structure of the haunch-bones of these creatures is quite different from that of the Iguanodon, and more like that of the crocodiles, so that it is perfectly evident that they exhibited no especial bird-like affinities. These reptiles may, indeed, be more correctly compared with crocodiles, which they resembled in walking on all four feet; although in many points of their organization they were allied to the Iguanodon, and thus indicate how the latter has probably been derived from reptiles more closely resembling crocodiles.

Fig. 3.—Outer Surface of the Tooth of the Hoplosaur. Nat. size.

The teeth of the Hoplosaur, although so unlike those of the Iguanodon, likewise indicate that their owners were of herbivorous habits. The gigantic bulk of these creatures is indicated not only by the arm-bone mentioned above, but also by another arm-bone obtained from the Kimeridge clay, which measures 57 inches in length, as well as by the thigh-bone of the allied Cetiosaur (whale-lizard) from the still older Stonesfield slate of Oxfordshire, which is upwards of 64 inches in length. The latter dimensions—stupendous as they are—are, however, exceeded by another thigh-bone from the United States, which actually measures upwards of 71 inches, or 6 feet 2 inches. The owner of this enormous bone has been appropriately named the Atlantosaur, and appears to have been the largest land animal yet known, alongside of which a full-grown elephant would be a mere pigmy. The total length of another nearly related but smaller American species is, indeed, estimated to have been as much as 80 feet.

Another peculiarity of these reptiles, which must not be passed over, occurs in the joints of the backbone, or vertebræ. In creatures of such enormous bulk, if the vertebræ were solid their weight would probably be an impediment to the free movements of the body; and we accordingly find that these vertebræ were excavated into hollow chambers. A similar feature is known elsewhere only in birds, where these chambers are filled with air. We must not, however, omit to mention that similar chambers occur in the vertebræ of the smaller members of the group under consideration.

(*To be continued.*)

THE BED-BUG.—II.

By E. A. Butler.

A FEW words are necessary to complete our picture of the bed-bug's head, for we have yet to speak of the antennæ and eyes. The former (Fig. 5) proceed from the upper surface of that part of the head which lies between the eyes and the base of the rostrum, and are remarkable for the small number of their joints, four only being discernible; the basal joint is small and stout, but the other three long, and, except the second, very slender, much finer, in fact, than a human hair. In the fewness and length of the joints of the antennæ, the bed-bug is quite in accord with the rest of the members of the division of Hemiptera to which it belongs, viz. the Heteroptera. One usually thinks of antennæ as composed of a great number of short joints, and such an idea would be correct for the vast majority of insects, but not for the Heteroptera, in which sub-order alone we find antennæ composed of a small number of long joints. Like all the rest of the body, the bug's antennæ are clothed with hairs, which are, no doubt, more or less sensory in function; those on the basal joints are much coarser and more thickly set than those towards the tip. The last joint, as will be observed from the figure, is slightly clubbed at the end, and is probably the most highly sensitive part.

The eyes are black and very prominent, appearing as two masses like little blackberries at the sides of the head, reminding one of the corresponding organs in certain small ant-like beetles (*Pselaphidæ*) which inhabit moss, or lurk under stones. The bed-bug is somewhat exceptional amongst Hemiptera in not possessing, in addition to its compound eyes, the small simple ones called "ocelli."

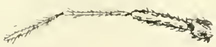


Fig. 5.—Antenna of Bed-Bug.

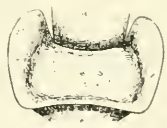


Fig. 6.—Prothorax of Bed-Bug. *h*, head; *s*, scutellum.

Two such are usually to be found, in this order, between the compound eyes, but our present insect is destitute of them.

The thorax, or, as we ought rather to say, the prothorax (Fig. 6) is curiously shaped, being much wider than long, and having broad leaf-like expansions of its chitinous covering at its sides; these run forward by the side of the head almost as far as the eyes, and so form a notch into which the head loosely fits, and whereby its sideward motion is considerably restricted, as if by a stiff collar. A similar peculiarity, viz. the winged margin to the thorax, will be familiar to microscopists as occurring in the little lattice-winged insects called "thistle-bugs" (*Monanthia cardui*), which are found abundantly on thistle-heads, and are often mounted whole as opaque objects for the microscope, under the name of *Tingis*. The other two segments which go to make up the complete thorax are not very easy to trace above, though evident enough beneath. The only part that appears prominently is a central triangular plate of the mesothorax, called the *scutellum*. On each side of this we see the fore-wings, which are in a very rudimentary condition, and, fortunately for our comfort and peace of mind, quite useless for flight.

In these little scale-like appendages can still be recog-

nised, though in a greatly abbreviated form, one of the essential elements of the hemipterous wing, and it will be necessary here to consider the general plan of the complete wing, if we are to understand the ridiculously reduced and utterly inefficacious scraps which the bed-bug retains, perhaps as the relics of a former superabundance. In hemipterous insects generally, then, the fore-wings, or rather elytra, are so constructed that some of the principal nervures divide them very distinctly into separate areas, at the junctions of which the wing can be angularly bent downwards; the degree to which this is the case varies in different species, and we will take one of the commonest insects we possess as illustrating a very usual type, and one of considerable complexity. During the summer months there may be found in profusion on many wayside weeds, as well as on plants in gardens, a bright green insect, a little over ¼ inch long, which by an inspection of its mouth, or by its odour, may be easily recognised as a member of the order Hemiptera. Its name is *Calocoris bipunctatus*, and it is an active four-winged creature, which readily takes to flight; a few specimens may easily be secured in a pill-box, and thence transferred to a killing bottle. After death, the fore-wings may be easily detached and mounted on white cardboard, when they will be ready for examination with a lens.

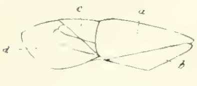


FIG. 7.—LEFT ELYTRON OF CALOCORIS BIPUNCTATUS. *a*, corium; *b*, clavus; *c*, cuneus; *d*, membrane.

Fig. 7 shows one of the elytra of this insect; the basal part is rather stiff and horny, and brightly coloured with green or orange; the tip is of much more delicate texture, being quite thin, flexible, and transparent, and devoid of bright colour. This difference of texture in the two parts of the wing, which is a very constant character, is the foundation for the name Hemiptera, *i.e.* "*half*-wings," as well as for that of Heteroptera, *i.e.* "*dissimilar* wings." The horny basal part consists of two areas divided by a flexible junction; the outer one, a four-sided piece, with two long and two short sides, being called the *corium*, and the inner, a roughly triangular piece, the *clavus*. At the margin of the corium furthest from the body is a small triangular or wedge-shaped area, almost as stout as the corium itself, but distinctly divided both from it and from the more remote part; it is called the *cuneus*. The rest of the wing, constituting the whole of the tip, is quite flexible and is spoken of as the *membrane*. When the elytra are closed (Fig. 8), the shortest sides of the two triangular clavi exactly meet on the back below the apex of the scutellum, while the inner edges abut on its sloping sides. The membranes, however, overlap one another, and the elytra then extend at least as far as the end of the body, not unfrequently projecting a little beyond it.

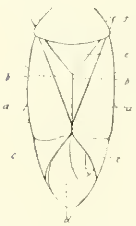


FIG. 8. — CLOSED ELYTRA OF CALOCORIS BIPUNCTATUS. *a*, corium; *b*, clavus; *c*, cuneus; *d*, membrane; *e*, scutellum; *f*, prothorax. The right membrane overlaps the left.

Such is one of the commonest types of fore-wing in the Hemiptera; but it is a peculiar fact that in this particular order the different areas of the wing seem possessed of varying degrees of stability, so to speak, and nothing is more common than for one or more of these parts either to be very much reduced in size or to remain altogether undeveloped, not as a mere accident in some one unfortunate individual, which may take place in any order, but as a permanent arrangement for the whole species. The membrane is the first part to be affected, and in many species it either disappears entirely or is reduced to a mere narrow border on the harder part of the wing. The cuneus is in many cases omitted altogether, and in the so-called apterous forms, of which the bed-bug is one, both the clavus and corium may be reduced to an indefinite extent. Now, in the bed-bug there is only one scale-like piece on each side without subdivisions; this is a rudimentary corium; clavus, cuneus, membrane, are all absent. The elytron, thus abbreviated, is a somewhat oval, reddish brown object (Fig. 9), very deeply punctured, *i.e.* covered with rounded pits, not perforations, which are technically called punctures. Similar punctures cover the whole body, except where the segments overlap, in which places the surface is smooth and polished, whereby friction is lessened; the punctures on the elytra are, however, larger than elsewhere, and each gives origin to a hair.

The hind-wings of the Hemiptera are as unstable as the fore-wings, and very generally, if the latter are abbreviated, the former are entirely absent. When present, they consist of an extremely delicate membranous expansion supported on a few nervures; they may be seen in one of their most beautiful forms in such insects as the Water Boatman (*Notonecta glauca*), or in the water-bugs called *Corixæ*. The bed-bug has no hind-wings at all.

FIG. 9.—LEFT ELYTRON OF BED-BUG.

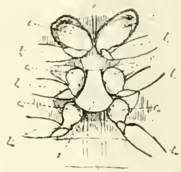


FIG. 10.—UNDERSIDE OF THORAX OF BED-BUG. *r*, tip of rostrum; $c_{,}$ $c_{,,}$ $c_{,,,}$ coxæ of 1st, 2nd, and 3rd pairs of legs; $l_{,}$ $l_{,,}$ $l_{,,,}$ 1st, 2nd, and 3rd pairs of legs; *s*, flap under which the scent of glands lie.

But there is a further puzzling peculiarity connected with the wings of the Hemiptera that is worthy of thoughtful consideration. Those species in which the wings are usually more or less imperfectly developed, occasionally yield individual specimens in which the full degree of development is attained, all the parts being present in their proper proportions. Such cases are usually rare, sometimes extremely so, and the causes which produce the fully matured forms still await discovery. Take, for example, a very common insect, the so-called Ditch Skater, or Water Cricket (*Velia currens*). Everyone will remember to have seen this creature living gregariously on the surface of ponds or streams, skating about in lively fashion, like a company of spiders enjoying an aquatic picnic. Almost always this insect is entirely destitute of wings, showing not even the merest rudiments of them. And yet, very occasionally, amongst a crowd of specimens, all of the ordinary form, there may be detected an individual with fully formed elytra and wings, and therefore capable of flight. But the occurrence is a most exceptional one, and the discovery of a *fully developed Velia* always marks a red-letter day in the diary of an hemipterist. And the same thing holds good of the majority of those bugs which as a rule have undeveloped wings.

Now, as our domestic pest is one amongst the number of these unfinished forms, the question arises whether it ever assumes the fully winged condition, and if so, what

it looks like then, and what its powers of flight may be. That such a disgusting insect should add to its resources the power of flight, whereby it might become increasingly annoying by settling on the bodies of respectable citizens as they walk the streets, and by regarding every open window in even well-to-do neighbourhoods as an invitation to enter, would immensely increase the loathing with which it is now regarded in respectable society, and it is a comfort to know that no record exists of winged bed-bugs having ever been met with in this country. There have been reports that such specimens have been seen somewhere in the East, but there appears to be no authentic record of any such occurrence; still, it is well to bear in mind that such a thing is a possibility, though most likely an exceedingly remote one. If wings were present, there would probably be no cuneus to the elytra.

The acquisition of wings by insects that are usually unwinged, of course greatly facilitates the spread of the species, which would otherwise have to trust, for extending the area of their distribution, to their own legs, or to conveyance upon or by means of some other animal gifted with superior powers of locomotion. As the bed-bug, however, has chosen to attach itself to the most migratory animal in the world, and gains all the advantage of man's artificial as well as natural means of locomotion, it would seem that a winged form is not a matter of such prime importance to it as to wild species that do not possess these extra advantages, and therefore the mere fact of the bed-bug's parasitism probably militates against its occurrence as a fully-developed insect.

There is not much externally to distinguish the sexes; in both the abdomen is broad and flat, but that of the male is rather the smaller and narrower of the two, and there are differences in the form of the terminal segments. In most of the field-bugs the abdomen is rather widely bordered on each side by a flat margin, distinctly marked off from the rest of the body. In the bed-bug, however, this margin, which is called the *connexivum*, is reduced to an exceedingly narrow line, and is scarcely perceptible.

Turning the bug over on its back, we now proceed to examine the underside. The chief point to be noticed here is the position and attachment of the legs. They are all let into hollows in the thorax, as usual, by the coxæ (Fig. 10). The coxæ of the first pair are almost close together, there being only room for the tip of the rostrum between them, but the other two pairs are separated by a considerable interval, and the space between them is occupied by a raised surface covering the glands by which the volatile fluid is secreted which imparts to the insects the disagreeable odour they are noted for. The glands open by a very fine aperture situated beneath a kind of flap, which runs from the mesothorax down between the coxæ of the hind legs.

In the possession of these odoriferous glands the bed-bug is by no means exceptional; it is one of the usual characteristics of the order, and the odour of some of the larger wild species is far more powerful, though of the same class. The liquid secreted is a colourless oily substance, and it would appear to be continually being given off during life. Its smell is of a compound nature, and a keen-scented person will detect, under-lying the more disagreeable elements, the scent of a freshly-cut cucumber. That the disagreeable character of the bed-bug's secretion is not due to the animal nature of its food appears from the fact that a precisely similar odour is exhaled by those species that subsist on vegetable juices. In some wild species the fluid seems to be of a different constitution, as it is quite pleasantly fragrant; *Coranus subapterus*, for example, a grey species which is found running on the ground in heathy and sandy places, exhales, when handled, a perfume which has been compared to that of jargonelle pears. But of whatever nature the scent may be, it is no doubt protective in function, and the insects are by its presence rendered nauseous and distasteful to birds and other enemies. The bed-bug does not seem, however, as it is now circumstanced, to derive much protection from its odour, for, apart from its presence being thus plainly advertised to man, the common cockroach will, notwithstanding the smell, devour it with avidity; and no doubt tragedies of this kind are of nightly occurrence in the slums of seaport towns, where both of these intruders have taken up their quarters and multiplied till their armies have amounted to tens of thousands. Here, then, is a good word for the cockroach, although it may fairly be questioned whether the remedy is not almost as bad as the disease.

(To be continued.)

VILLAGE COMMUNITIES.*

By Canon Isaac Taylor, Litt.D., LL.D.

OUR knowledge of primitive civilization is derived largely from the study of survivals. Survivals may be defined as anomalous traditional usages, seemingly meaningless or useless, which originated in some state of things which has passed away, but which by the force of custom have continued to exist. That the Queen still gives her assent to Acts of Parliament in a formula couched in Norman French is, for instance, a survival from the time when the sovereign of England was a Norman Duke, unable to speak English. A judge's wig is a survival of the long hair which came into fashion at the Restoration; and the black patch on the crown, with its white fringe, is a survival of the black skull cap that was worn over the coif of white silk or linen which formed the head-dress of the serjeants-at-law from whom the judges were selected. The procurations paid to an archdeacon are a money composition in lieu of his ancient right of quartering himself and his attendant horsemen on the parochial clergy during his visitations. Fee-farm rents, as they are called, are in many cases survivals of payments for services no longer rendered. The writer pays a fee-farm rent of 5s. 4d., which represents a composition for a certain number of thraves or sheaves of corn, which his predecessors in title rendered to the abbot of Beverley, for his services in "correcting the villans" of a certain parish who might avail themselves of the privilege of sanctuary which was conferred by Athelstan on the monks.

The unchronicled history of our English villages is largely to be recovered from the study of such anomalous survivals. Sir Henry Maine and Mr. Seebohm in this country, Von Maurer and Professor Nasse in Germany, have led the way in such researches, and Mr. Gomme has proved himself a diligent disciple of these masters of the science. Ten years ago, in his book on *Primitive Folk Moots*, he collected a number of cases of survivals of local self-government as exercised in open-air shire-moots, hundred-moots, and manorial courts; and more recently, in his *Literature of Local Institutions*, he has compiled a useful bibliography of the subject. The editor of the Contemporary Science Series has there-

* *The Village Community: with special reference to the Origin and Form of its Survivals in Britain.* By G. L. Gomme. [Contemporary Science Series.] London: Walter Scott, 1890.

fore been fully justified in entrusting the volume on Village Communities to an expert who has earned for himself a title to respectful audience.

It may be said at once that Mr. Gomme's book is full of curious and interesting matter, diligently gleaned from sources often obscure, and sometimes inaccessible to ordinary students. Unreserved commendation may be given to several of the chapters, especially those dealing with archaic customs relating to allotments of land in common fields, to co-operative tillage, the rights of commoners, and the gradual transformation of communal rights into freehold or copyhold tenures. The account of certain municipal customs in London, and of the punishment of offences against customary law, are also valuable and interesting. So, too, is the explanation of the duplicate municipal jurisdiction which prevailed at Rochester, the extramural community at Boley Hill being probably of Danish origin, and governed by its own laws and officers, subordinate to the rule of the intramural Saxon community. Mr. Gomme omits, however, the still more striking case of Exeter, where Mr. Kerslake has succeeded in delimitating the boundaries of the Celtic and Saxon communities which dwelt side by side within the walls.

So long as Mr. Gomme confines himself to matters as to which he is acknowledged to be an expert, we may follow him with confidence. But when he attempts to fulfil the promise given on his title-page, of dealing with the "origin" of village communities, he is entangled by ethnological and anthropological problems with which he is less competent to deal. He defines it as "the special object of the present inquiry to establish, if possible, that the pre-Celtic inhabitants of this island must have lent their aid in the fashioning of British institutions" (p. 295). This being "the special object" of his book, by his success or failure in this attempt the book must be judged; and the verdict must reluctantly be pronounced that the attempt has altogether failed. Mr. Gomme believes that our village communities are to be traced to what he calls an "Iberic" origin. But he adduces no evidence as to the nature of Iberic institutions in the lands where, if anywhere, they may have survived—in Corsica, Sardinia, Spain, Auvergne, Southern Italy, or among the Basques and the Kabyles. Instead of this he goes for his type of "Iberic" institutions to the non-Aryan hill tribes of India, who have never been supposed, even by the wildest of ethnologists, to have any connection with the Iberians.

In endeavouring to discriminate between what he calls the Aryan and the pre-Aryan institutions of Britain, Mr. Gomme refers continually to the Indian communities, but he does not describe or discuss the Russian *mir*, which presents, even in our own day, an almost perfect example of the unchanged village community whose institutions he is striving to deduce from Indian parallels and obscure English survivals. He actually quotes from Sir Henry Maine the statement that these Russian communities have survived in a more archaic state than those of India (p. 262), but he inexcusably excuses himself from investigating them on the ground that, owing to the limits of his work, "there has been no opportunity of examing the village community as it survives in the Russian *mir*" (p. 295). Avoiding the ground on which he might have trod firmly, namely, a comparison between the village institutions of the Basques and other Iberian peoples on the one hand, and those of Russia on the other, he goes off on a Quixotic endeavour to establish analogies between the non-Aryan village life of India, Borneo, Fiji, and South Africa, and what he conceives to be survivals of the pre-Aryan institutions of England.

He shows reasons for believing that in our own village institutions we may detect traces of the existence, side by side, of a conquering race and a subject race. The conquering race he identifies with the Aryan invaders, and the subject race with neolithic tribes of Iberian or Silurian blood. The whole of this argument is vitiated by two fundamental fallacies, from which a more intimate acquaintance with recent ethnologic and anthropologic investigations would have saved him. In the first place he takes for granted the now exploded doctrine that Aryan blood is co-extensive with Aryan speech, and therefore that both Celts and Teutons are alike Aryans by race, whereas few anthropologists would now admit that the dolichocephalic Teutons could have belonged to the same race as the brachycephalic Celts. Before drawing any comparison between the institutions of India and England, it is necessary to determine whether the Indian Aryans are cognate with the Celts or the Teutons. Cognate with both they cannot be. In fact, almost all the anomalies which Mr. Gomme refers to the contact of Aryans and Iberians on our shores may be explained as being due to contact between Celts and Teutons.

Mr. Gomme's second fallacy is the identification of the pre-Aryan races with the neolithic people; whereas it may now be regarded as established that the Aryan invaders were themselves in the neolithic stage of culture when they reached our shores. Mr. Gomme's neolithic Iberians turn out, therefore, to be merely Celts still in the neolithic stage. Not only were the early Aryan occupants of Europe a pastoral neolithic people, but it is also certain that the Aryan invaders of India were merely pastoral nomads who had not reached the settled agricultural stage. The undivided Aryans must have separated before they had learned the use of metals, and before they settled in villages or had framed the laws and customs regulating tillage, which are needed in agricultural communities. Hence all parallels between the Aryan agriculture and the Aryan village institutions in India and in England are necessarily fallacious. Both must have grown up at a time subsequent to the pastoral stage, during which the separation of the Aryan races must have taken place.

Mr. Gomme not only compares the Aryan village organizations in India and England, which must necessarily have arisen independently, but he constantly draws parallels between the non-Aryan hill tribes of India and the people who built the forts and earthworks on the hills of Britain, and whom he unhesitatingly regards as Iberians. But these earthworks on our hills, from their relation to pre-existing Roman roads, can in some cases be shown to be actually post-Roman. The hill-folk of Gaul were undoubtedly in many cases, if not invariably, of Celtic race, and it is highly probable that the people who in Britain must have defended themselves in hill forts against invaders were Celts, who resisted either the Romans or the invading Anglo-Saxons, and not Iberians who resisted the invading Celts. Archæology supplies no evidence whatever that the pre-Celtic people of Britain were capable of constructing the vast earthworks which crown so many of our hills, whereas we know, in many instances, that they were built by Celts. Mr. Gomme's main thesis must therefore be held to have broken down completely. No trustworthy evidence has as yet been brought forward to show that the origin of the village communities in England can be referred to the pre-Aryan Iberic people of Britain. If Mr. Gomme had been content to eschew such startling theories—improbable, unproved, and probably unprovable—and had satisfied himself with giving a digest, which his ample erudition would have enabled him to do,

SAXIFRAGA PYRAMIDALIS.

The herbaceous Saxifrageæ are related in several respects to the Crassulaceæ or Stone-crop order.

of the actual facts, his book would have merited almost unreserved commendation.

It may be added that his reading, though extensive, has by no means been exhaustive. Among the more important sources of information which he has overlooked may be enumerated the *Rectitudines Singularum Personarum*, a most valuable Anglo-Saxon treatise on village customs and the rights and duties of officials. To this treatise, which should have been his text-book, he only once refers, and that at second-hand. The evidence of the Boldon Book, as compared with Bishop Hatfield's subsequent survey of the same baronies, as well as the Black Book of Hexham, would have supplied valuable evidence as to early tenures, and the gradual changes which took place in them with the lapse of time. The volume of *Domesday Studies*, which was the fruit of the Domesday Commemoration of 1886, with which he does not seem to be acquainted, would also have elucidated some obscure points relating to communal tillage, land measures, and taxation.

NOTES ON PHYLLOTAXY, OR THE MATHEMATICAL ARRANGEMENT OF LEAVES AND BRANCHES.

By J. Pentland Smith, M.A., B.Sc.

THE flowering plant shown in the plate *Saxifraga pyramidalis* has become very popular of recent years, by reason of its fine trusses of flowers and hardy character which render it suitable for house decoration. As its generic name would imply, it belongs to the family, or Natural Order, Saxifrageæ. The plants which make up this Natural Order all possess two seed-leaves or Cotyledons, and are included in that large group of plants known as Dicotyledons. Furthermore, as the stamens, or male organs, and the petals, or coloured portions, of the flower, appear to arise from the modified green leaves, the sepals, occupying the periphery of the flower, the Saxifrageæ are classed under that division of the Dicotyledons termed the Calycifloræ. The plants belonging to the Order of Saxifrageæ, are allied to those forming the Leguminosæ (Pea family), Rosaceæ (Rose family), and Crassulaceæ (Stone-crop family). In the Rose there are glands at the base of the pistil or female part of the flower, which are absent in the Saxifrages. In this Order are found the Australian pitcher-plant, and as first cousins of the specimen before us we may rank the familiar Gooseberry and the Red and Black Currants.

It is rather curious to find that the Saxifrages obtained their name from a remarkable property which they were supposed to possess, viz. that of breaking stones (*saxum*, a rock, and *frango*, to break) in the bladder.

The arrangement of the leaves and flower-bearing branches shown in the picture may at first appear to be quite fortuitous, but a closer inspection will satisfy the student that a definite law governs the arrangement, not only of the leaves around the foot, but also of the flower-bearing branches which spring from leaves at their base or junction with the central stem or axis of the pyramid of flowers.

A plant derives in part its characteristic appearance from the manner in which the leaves arise from the stem. The arrangement of the leaves on the stem is termed *phyllotaxis* (Greek φυλλον, a leaf, and τaξις, arrangement). At first sight it appears that the leaves are scattered on the stem without any regard to order or regularity; but by an attentive examination it can be seen that here, as in other departments of Nature, the reign of law can everywhere be traced, and that a stem always sends forth its leaves subject to mathematical laws. The arrangement of the leaves and branches varies with different plants: sometimes the phyllotaxis even changes on different parts of the same plant, and sometimes it remains constant throughout a whole genus, and occasionally a certain phyllotaxis is characteristic of a whole order or natural group of plants—for example, in the *Labiatæ*, the Dead Nettle Order, the leaves are always placed opposite to one another.

Besides the *opposite* arrangement just cited, there is the *whorled* arrangement, in which three or more leaves appear at the same level on the stem, and the *scattered*, or *alternate*, arrangement, in which each leaf arises at some distance from its neighbours. The points at which the leaves arise are termed the *nodes*, and the intervals between them are termed *internodes*.

The internodes may be extremely short, as for example in *Pandanus*, the Screw Pine, in the House Leek, and the lower portion of the stem of the Saxifrage of our illustration. There it can be seen that the leaves form a spiral or *helix*, which winds round the axis on which they arise. This is particularly visible in the Pandanus, as anyone who has visited the Palm House at Kew must have noticed, and in this case the spiral seen is what is termed the *genetic* spiral. It is so called because it includes in it every leaf as it develops. It is the spiral of growth.

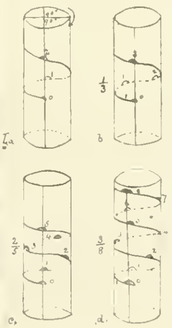


Fig. I.

In stems in which the alternate arrangement of leaves prevails, such as those of our common forest-trees, there are great differences both as regards the length of the internodes and the number of leaves which have to be passed over, in tracing out the genetic spiral, before a leaf is arrived at which is disposed vertically above the one with which the observer has started. Take a twig of the Elm or Beech, select a leaf, then trace out a spiral which will include every leaf. Calling the first leaf 0, and numbering the successive leaves 1, 2, 3, 4, and so on, you will find that leaf No. 2 is superposed to leaf No. 0, and that the spiral you have described has wound once round the stem (see Fig. I. (*a*)); thus the distance, or *angular divergence* between any two leaves in the spiral is one-half the circumference of the stem, or 180°.

Had a branch of the Elder or Aspen been selected, in describing one turn round the stem leaf No. 3 would have been found vertically above leaf No. 0 (see Fig. I. (*b*)), and the angular divergence would have been 120°. Two turns of the spiral must be made in the case of the young shoots of the Oak or Willow before two leaves are found in a vertical line, and then 5 stands above 0, thus making the angular divergence 154°, and the spiral a $\frac{2}{5}$ arrangement (see Fig. I. (*c*)).

In the Holly, leaf No. 8 stands vertically above leaf No. 0, and the spiral has passed three times around the circumference of the stem; hence the angular divergence is $\frac{3}{8}$ of 360°, or 135° (see Fig. I. (*d*)). An angular interval of $\frac{5}{13}$ is seen in the Lily and in the cones of *Pinus strobus* (the Weymouth Pine), and of $\frac{8}{21}$ in the cones of many other Pines. Placing these fractions together, we get a series—$\frac{1}{2}$, $\frac{1}{3}$, $\frac{2}{5}$, $\frac{3}{8}$, $\frac{8}{21}$, etc., which can easily be remembered, as the

sum of the numerators of any two adjacent fractions is the numerator of the succeeding fraction; and the same law holds good for the denominators.

This series of fractions is very commonly found in dealing with phyllotaxis, and has been termed by botanists the Ordinary system. But other fractions are met with in phyllotaxis which cannot be referred to the above series. These form the two series $\frac{1}{4}$, $\frac{2}{7}$, $\frac{3}{11}$, $\frac{5}{18}$, . . . and $\frac{1}{4}$, $\frac{1}{5}$, $\frac{2}{9}$, $\frac{3}{14}$, . . . They have been called the Secondary and Tertiary series respectively. As in the Primary so in these the sum of two adjacent numerators gives the succeeding numerator, and the sum of two adjacent denominators the succeeding denominator; but they differ from the first inasmuch as in it the numerator of any one fraction is the denominator of the next but one preceding. Still, the three series are connected with one another, for the numerator and denominator of any one fraction in the Primary series furnishes us with the denominator of the corresponding fraction of the Secondary series, and the numerator and denominator of any one fraction of the Secondary gives the denominator of that fraction in the Tertiary series.

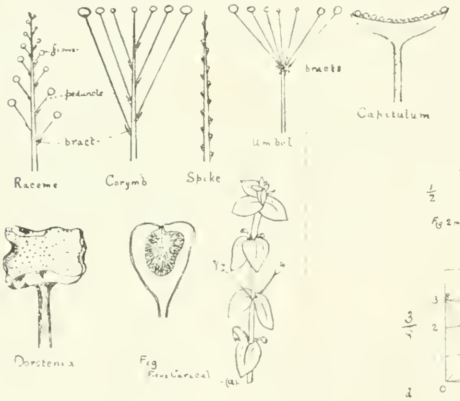


FIG. III.

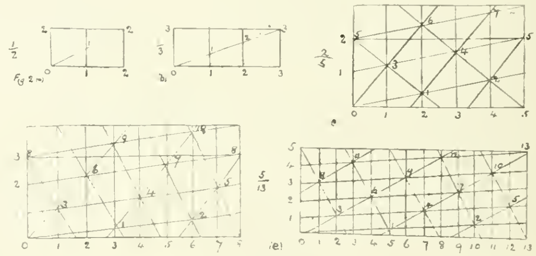


FIG. II.

In the case of the phyllotaxis represented by the fraction $\frac{1}{2}$, the leaves are disposed in two vertical rows on the stem; in the $\frac{1}{3}$ arrangement there are three vertical rows; in the $\frac{2}{5}$ five rows, and so on. The denominator of the fraction gives the numbers of the rows in each case. This must needs be so, as it indicates the number of leaves which are passed in the genetic spiral from the leaf with which the spiral may be supposed to commence to that which is placed vertically above it. These vertical rows are called *orthostichies* (ὀρθος straight, and στιξ a row). They may be clearly seen on reference to Fig. II. (*a*, *b*, *c*, *d*, *e*), in which the bark of the stem is supposed to be unrolled, and placed flat on the paper.

It will also be noticed that spirals other than the genetic spiral—*secondary spirals*—can be traced on the diagrams. These are not so evident when the leaves are placed at a distance from one another, but when they are developed close together they are very easily noticed, and in fact they often obscure the genetic spiral. The lines which trace them out are termed *parastichies*. The number of parallel parastichies in one direction can be found by subtracting the number of one leaf from that of the one next it on the same parastichy. Thus in the case of the $\frac{2}{5}$ spiral there are three parallel parastichies to the right. In one of these we find the figures 1, 4, 7; subtracting one from four we get three, which is the number of parastichies to the right; in one of those to the left we meet with the figures 2, 4; two from four gives two, the number of parallel parastichies to the left.

It is often a matter of extreme difficulty to determine the genetic spiral, but by taking any two secondary spirals which cut one another, that is one to the left and another to the right, it may be made out with comparative ease. Take the number of parallel parastichies in one direction, and number the leaves as stated above; for instance, in the case just cited, as there were three parallel parastichies to the right, the leaves of one of these would be numbered 1, 4, 7, and so on, and the others would also be numbered after the same fashion. Then pick out the parallel parastichies to the left, which cut the former; presuming there were two, the leaves of the one which arose nearest the one formerly selected would be numbered 2, 4, 6, and so on. The whole of the leaves could thus get their correct numbers, after which the tracing of the genetic spiral would be a matter of no difficulty. This method is followed in complicated cases where the leaves are very close to one another, such as in the Pine-cones, and in the capitula of the Compositæ; for example, in tracing the order of the arrangement of the florets of the Sunflower.

We have already stated that the arrangement of leaves may be opposite, whorled, or scattered. In the first case it generally happens that the adjacent pairs stand at right angles to one another on the stem, giving what is termed the *decussate* arrangement, ex. *Anagallis arvensis* (Fig. III. (*a*)). The whorled arrangement is seen in many of the *Rubiaciæ*; ex. *Galium cruciata*, or Crosswort, one of the Bedstraws. It has been suggested that the alternate arrangement of leaves is the normal one, and that the whorled arrangement has arisen by suppression of the internodes. In support of this view, Mr. G. E. Massee writes in *Nature* of 12th July 1877, stating that in *Lysimachia nemorum*, a small plant with yellow flowers, which is found in abundance carpeting our woods in early summer, the leaves are opposite, but that the flowers springing in the axils of the opposite leaves are never both equally developed at the same time, the one being expanded while the other is in bud; and also that the oldest or most fully developed flower appears alternately on opposite sides of the stem.*

The axis or stem on which the flowers arise is the *floral axis*, and its mode of branching is termed the

* In reality in *Lysimachia nemorum*, according to Mr. G. E. Massee, the first-formed flower alone belongs to the stem of the plant; the others are all that is left of aborted branches which have developed from one another in such a way as to give the appearance of a single stem.

inflorescence. Inasmuch as the branches generally arise in the axils of leaves the phyllotaxis is intimately connected with the inflorescence, so that the consideration of the one leads naturally to the discussion of the other.

The leaf which subtends a flower is generally much simpler in structure than the ordinary leaf; it is called a *bract*. It is sometimes coloured,* as for instance in *Clerodendron*, a climber which grows to profusion in one of the glass-houses at Kew, in which they are white, and so set off the brilliant crimson flowers. The stalk of the flower is termed the *peduncle*; on it generally arise one or two small leaf-like organs, called *bracteoles*. In Monocotyledons (ex. Hyacinth) there is one, in Dicotyledons (ex. Mallow) two; thus the number of bracteoles on a peduncle is the same as that of the cotyledons or seed-leaves with which a plant is furnished.

The forms of inflorescence seem endless to the tyro in botanical lore, but they can all be referred to two main types—the *Racemose* and *Cymose*. Of course, we do not include in our classification those varieties of branching to which the floral axis seems subject when exhibited on wall-papers. The floral axis may grow on indefinitely, producing leaves in the course of its growth; in the axils of these leaves flowers or groups of flowers may arise, and ultimately the axis itself may terminate in a flower. When such is the case, an *indefinite* or *racemose* inflorescence is the result. As the oldest leaves and flowers are at the bottom of the shoot, and the youngest near the apex, this form of inflorescence has also been termed the *centripetal* or centre-seeking. The significance of this last name will be evident from the diagram (Fig. IV. (*b*), (*c*), in which the observer is supposed to be looking upon the inflorescence from above and to see the helix or spiral winding snake-like round the floral axis until it at last reaches the object of its desire, the apex of the shoot itself. Racemose inflorescences are very common, and perhaps the raceme itself is as frequently met with as any. We may first cite the *solitary axillary* form, ex. *Anagallis arvensis* (Fig. III. (*a*)), where a single flower arises in the axil of each leaf of the ordinary stem. The *Raceme* is a floral shoot which generally bears leaves, and in the axils of each of these leaves a single-stalked flower arises (ex. Mignonette and see Fig. III.). Being a form of indefinite inflorescence, the oldest flowers are of course situated at the base of the shoot. In the corymb (Fig. III.) the flower-stalks or peduncles of the raceme have elongated so as to bring all the flowers to the same level, while in the spike (ex. *Verbena officinalis* and see Fig. III.) the peduncles have not developed, and so the flowers are *sessile*. Contract the main stem of the raceme and the umbel is formed (ex. *Hedera helix*, the Ivy, and see Fig. III.), and telescope the floral axis of the spike and the result will be the capitulum (Fig. III.); ex. *Bellis perennis*, the Daisy. Slightly invaginate the capitulum of the Daisy and the inflorescence seen in Dorstenia will appear; and continue the invagination, and you will get the hollowed-out floral axis of the *Fig* (Fig. III.). These various forms thus all lead into one another.

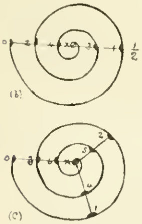


Fig. IV.

A *Cymose*, or definite inflorescence, is produced when the main stem ends in a flower. The simplest case is the *solitary terminal*, in which no further development takes place, ex. Gentianella. But generally a bract appears before the flower arises, and in the axil of it a lateral stem appears, which in turn ends in a flower, but before doing so also produces a bract, in the axil of which stem number three arises; and so on. This is a *uniparous* form of cymose branching, which generally results in the formation of a false axis or *sympodium*, because the upper portion of each stem unites with the basal part of the succeeding stem, thus giving the whole inflorescence the appearance of a single racemose shoot. Its true origin can be detected by the fact that the leaves are not at the base of the flowers, but are situated either at the side of them or opposite them (see Fig. V. 2 (*b*), 3 (*b*)). If the branching take place continually on one side a *helicoid* cymose, a very uncommon form, is produced. This is so called because the whole branch system appears like a helix or spiral when the angular divergence of the successive branches is less than one-half (see Fig. V. 3 (*a*) and 3 (*d*)), the latter of which is a ground-plan of such a case. Were it only half, the ground-plan would represent the order of development as a straight line (Fig. V. 2 (*c*)). The *scorpioid* (ex. Helianthemum, Rock Rose) is the result of the successive

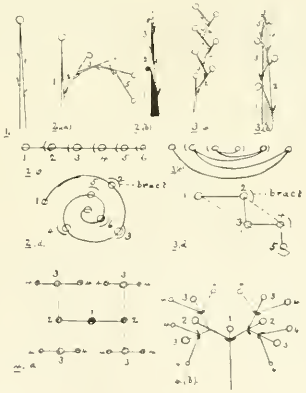


Fig. V.

branches appearing first on one side and then on the other, so as that in the ground-plan we have the appearance of a zig-zag or scorpion's tail (Fig. V. 3 (*a*), (*c*), (*d*)). The flowers of *Stellaria*, the Stichwort, order *Caryophylleæ*, furnish splendid examples of another form of cymose inflorescence—the *biparous*. In these the main axis ends in a flower as before; but here, instead of producing one bract before so doing, it produces two situated opposite one another, and in the axils of each a flowering shoot arises. These in turn branch, and so on, until there appears an inflorescence like that diagrammatically represented in Fig. V. (*b*), in which (*c*) is a ground-plan. It often happens that the main stem and the successive stems do not elongate after the production of the pair of bracts, so that when the flower which terminated each has died away, each shoot appears to have divided in a bifurcated or *dichotomous* manner. The term "falsely dichotomous" is used in describing such an one; the Miseltoe affords a good example of it.

As illustrating the two types of inflorescence only simple types have been cited; but, besides these, there are compound forms in each division, and the two divisions are linked to one another by mixed forms or those which combine the characters of both. These are exceedingly

* In botanical language an organ which is not green is said to be coloured.

common, as, for example, in the very large order Umbelliferæ, to which the stately Cow-parsnip and the deadly Hemlock belong, the inflorescence is generally an umbel of umbels; the Horse chestnut, *Saxifraga umbrosa*, and probably also *Saxifraga pyramidalis*, have a raceme of scorpioid cymes; in Vernonia centiflora there is a raceme of capitula, while the white Dead Nettle (*Lamium album*) furnishes an example of a raceme of contracted scorpioid cymes. Extreme aggregate beauty and enormous development often characterise such inflorescences; that of *Saxifraga pyramidalis* appears like a huge cone, whose base is the cluster of foliage leaves, while from amidst the group of succulent leaves of the so-called American aloe (*Agave americana*)—which, by-the-bye, is not an aloe, but an agave, as its botanical name shows—there springs up a huge compound indefinite inflorescence which often attains a height of from 24 feet to 36 feet, and whose constituent flowers may reach the enormous and almost incredible number of four thousand. The plant is so exhausted by this supreme effort that it dies down to the ground, and does not recover itself for some time. In its native Mexico it does not flower until the sixth or seventh year of its life, but when grown in greenhouses in this country from forty to sixty years generally elapse before it can summon up enough energy to enable it sexually to propagate its species; hence the origin of the tale dear to gardeners, that the American aloe flowers only once in a hundred years.

ON THE CONSERVATION OF ENERGY.

By J. J. Stewart, *Demonstrator of Physics at University College, London.*

ONE of the most remarkable features in the intellectual growth of the present century is the rapid advance made in physical science; and unquestionably one of the grandest of recent generalizations, which marks a distinct advance in philosophy as well as in science, and gives us, as it were, a vantage ground from which to attack with greater power future problems, is that which is known as the Principle of the Conservation of Energy. This theory has been gradually unfolded within the present century, chiefly through the researches of such men as Dr. Joule and Sir William Thomson in our own country and Helmholtz in Germany. The law of conservation is that great principle which tells us that the energy in the universe is not many but *one*, and though it can be neither added to nor diminished by man, it can yet be changed by him from one into another of its ever varying forms. As the fact that matter is indestructible forms the foundation of modern chemistry, so the fact that the quantity of energy, or power of doing work, implanted in the arrangements of matter around us, can neither be diminished nor increased, is now the basis of physical science. This pregnant truth has now become a most powerful instrument of research, and has not only led to numerous discoveries in the past, but is of the utmost value in suggesting the right methods by which to prosecute further inquiries into the mysteries of matter.

The law connecting the manifestations of energy cannot be proved by any one experiment; it has been slowly led up to by the observation of many facts, and by the reasonings founded on those observations. It is, moreover, being confirmed every day through the observation that no phenomenon in the physical world fails to completely accord with it when once it has been thoroughly investigated by the instruments at our command. Its truth is also powerfully brought home to scientific men when it is found that theories assuming its existence are able to *predict* what will occur in given circumstances, this prediction being fulfilled when an experiment is made under the conditions supposed. On the whole, no physical axiom has a more sure basis than this great law.

Science owes much to those ingenious but deluded men who gave so much of their time to the search for Perpetual Motion. This quest was, of course, not for mere continuous motion, but for a machine which could do useful work without the expenditure of power upon it; in other words, give out work, such as raising a weight or pumping up water, without taking in energy from the outside. This the statement of the law of the Conservation of Energy declares to be impossible. No truth in physics reposes on a firmer or more extended basis, for none has been investigated by a greater number of the ablest and most ingenious men, or with greater ardour and determination. The negative result arrived at by them, though disappointing to themselves, has led to the advancement of science as represented to-day by modern physics. As the search for the philosopher's stone and the elixir of life by the old alchemists resulted in the discovery of many useful and valuable facts incorporated now in our developed chemistry, so the pursuit of Perpetual Motion has not been without permanent and important results.

The word "energy," in its physical sense, was first employed by the philosopher, Dr. Young, and is a felicitous adaptation of a word in ordinary use to express a definite scientific idea. Energy may be defined as the power of doing work. Thus a cannon-ball when it has been fired from a gun possesses energy which is exhibited in its capability of shattering obstacles. The amount of its energy depends partly on its mass; a ball weighing twice as much as another has an energy twice as great if the two move with the same speed. But the energy is not simply proportional to the velocity. A ball moving at twice the rate of another is capable of piercing four times as many thin plates as the slower ball, that is, its energy depends on the square of its velocity. If the speed becomes four times as great, the energy is increased sixteen-fold. The recoil of a gun is a familiar instance of equality of action and reaction. The gun is driven backwards at the same time that the bullet is projected forwards, and the mass of the gun multiplied by its velocity of recoil is equal to the mass of the shot multiplied by its velocity in the opposite direction. But the bullet is capable of exerting a very different effect from that of the gun-stock, owing to its rapid motion. There is another form of energy due to position, like that of a head of water in a mill-pond, which is capable of doing work by turning the wheel during its fall to a lower level. A wound-up watch spring, a bent bow, wind, compressed air, heat, electric currents, are examples of energy associated with matter.

The energy which a body has on account of its position is called "potential energy," that which it possesses due to its motion is named "kinetic energy." An example of the change of potential energy into the kinetic form, and of kinetic energy back again into potential energy, is given by the pendulum. When it is at the highest point of its swing it is for a moment at rest, and its energy is entirely potential. By the action of gravity upon it, it is caused to descend till it is at the lowest point of its path, when it can fall no further and is then moving most rapidly—its energy is at this point entirely kinetic. Its energy of motion carries it through this point, and is changed into potential energy again at the other extremity of its course; the energy the pendulum possesses at points intermediate between its highest and lowest positions being partly of one kind and partly of the other.

CAYENNE ECLIPSE EXPEDITION.

Photographs taken by Mr. Burnham of Instruments standing in the French Fort from which the Eclipse was observed. The upper right-hand picture is an Instantaneous Photograph of a Street in Cayenne.

Direct Photo Eng. Co., Limited, 9, Barnsbury Park, N.

When a moving body is brought to rest by such forces as friction its energy seems to disappear—no equivalent of potential energy seems to be produced, and it was long thought that the work done against friction was lost. It is only in comparatively recent times that it has been recognised what becomes of the energy which is thus lost sight of, and that the principle of the conservation of energy has been established.

Professor Clerk Maxwell has stated the principle of the conservation of energy in the following concise form: "The total energy of any body or system of bodies is a quantity which can neither be increased nor diminished by any mutual action of these bodies, though it may be transformed into any one of the forms of which energy is susceptible."

An important addition was made to the knowledge of energy and its manifestations when the true nature of heat was discovered. By the old philosophers heat or "caloric," as it was termed, was considered to be a substance—an imponderable fluid, the addition of which to a body made it hotter. Lord Bacon, however, seems to have come to the conclusion that heat consisted of a kind of motion or "brisk agitation" of the particles of matter. In one passage he says: "It must not be thought that heat generates motion, or motion heat—though in some respects this is true—but the very essence of heat, or the substantial self of heat, is motion and nothing else." The true immaterial nature of heat could not be more clearly stated than it is in these words, but for long after Bacon's time the idea of the fluid "caloric" was universal.

About the end of last century Count Rumford published an account of some experiments made by him. He had been engaged superintending the manufacture of cannon at the arsenal of Munich, and was surprised at the amount of heat produced in the boring of the cannon. He made measurements of the rise of temperature obtained in different cases, and having considered the various possible sources of the heat developed, came to the conclusion that it was in reality due to the friction of the boring tool on the brass of the casting. "It is hardly necessary to add," he says, "that anything which any insulated body or system of bodies can continue to furnish *without limitation* cannot possibly be a *material substance*; and it appears to me to be extremely difficult, if not quite impossible, to form any distinct idea of anything capable of being excited and communicated in the manner that heat was excited and communicated in these experiments except it be *motion*." About the same time Sir Humphry Davy melted two pieces of ice by rubbing them together, whilst all surrounding bodies were kept at a temperature below freezing-point. This experiment shows that heat cannot be a substance, although Davy did not quite realise this fact at the time.

The most elaborate and important series of experiments on the transformation of mechanical motion into heat were those performed by Joule near Manchester, between 1843 and 1849. He caused paddles to rotate between fixed vanes in a vessel of water, the motion of the paddles being produced by the fall of a weight through a measured distance. The work done by the falling weight was transformed through friction of the water into heat, and a rise of the temperature of the water was produced. The distance through which the weight fell being accurately observed, the mechanical energy expended was known, and the amount of heat developed was shown by the rise of the temperature of the quantity of water used through a definite number of degrees. By a large number of experiments of this sort, made with great precautions to ensure accuracy, Joule determined that the amount of mechanical work represented by the lifting of one pound through 772 feet would, if transformed into heat, raise one pound of water 1° F. in temperature. This amount of mechanical work—772 foot-pounds, as it is called, taking as amount of work the quantity required to raise one pound through one foot against the attraction of gravity—is called the *mechanical equivalent of heat*. Another way of expressing the same thing is to say that if a quantity of water fall through a height of 772 feet, and then be suddenly brought to a standstill, its temperature will thereby be raised one degree. This would be the case in a waterfall of that height; if the heat did not escape, the water below the fall would be one degree hotter than that above.

What does the heat consist of which can thus be produced by the transformation of the energy of a falling body? There can be little doubt that it consists of the rapid motion or vibration of the minute particles of which the body is composed. Our knowledge of these vibrations can only be got at indirectly on account of the extreme minuteness of the molecules of matter; but it seems to consist of a rapid backward and forward motion, somewhat analogous to the motion of the particles of a sounding body. Mechanical work, as we see in the case of a steam engine, can be produced from heat. When this takes place it is found that to produce a given quantity of work a certain definite amount of heat must cease to exist. Under whatever conditions heat is changed into mechanical energy, it is found that the heat which has passed out of existence is equal in quantity to the amount which is mechanically equivalent to the work generated.

CAYENNE ECLIPSE EXPEDITION.

THE photographs shown in the plates were taken by Mr. Burnham in Cayenne, where he went to observe the eclipse of December last. The upper picture on the right-hand side is a photograph taken in full sunlight in one of the streets of Cayenne. The exposure must have been very short—probably less than the $\frac{1}{100}$th of a second, for the feet of the woman descending from the kerb-stone behind, and to the right of the child with the sunshade, appear perfectly sharp when examined with a magnifier. The centre of gravity of a person walking along at a rate of three miles an hour moves through a little more than 52 inches in a second, and the feet when stepping forward must move at at least double the rate of the body, or at more than 100 inches in a second. A motion of an inch in a direction at right angles to the line of sight during the exposure would produce a recognisable blur; but no such blurring of the feet is recognisable in any of the figures, though the feet are shown in all parts of the step.

The lower picture on the right hand was taken a few minutes after the total phase was over. It represents the observers round the principal group of instruments, with a few natives looking on. The negress to the right hand wears the characteristic Cayenne head-dress—a flat board covered with white cotton cloth. The observing-place was within a French fort. It was not found necessary to erect any tents or temporary wooden houses over the instruments; when left for the night, they were enveloped in tarpaulins.

The picture on the left shows a photographic telescope equatorially mounted with driving-clock, and the weights run down. The photographs obtained during the eclipse

show an extensive corona with curving polar rays symmetrical with respect to the sun's axis and of the usual sun-spot minimum type.

Mr. Burnham has sent a packet of most interesting photographs taken by him in and around Cayenne. We hope on some future occasion to reproduce some more of them for the benefit of readers of Knowledge.

Notices of Books.

The Philosophy of Clothing. By W. Mattieu Williams, F.R.A.S., F.C.S. (Thomas Lawrie; London, 1890.) This little book, like *The Chemistry of Cookery* by the same author, discusses in a fresh and original manner the philosophy of many common-place things. It gives an excellent account of several of the useful discoveries of that remarkable philosopher, Benjamin Thompson, who commenced life as a poor American schoolmaster, became Colonel Thompson of the British Army, Sir Benjamin Thompson the British Diplomatist, and ultimately Count Rumford, Privy Counsellor and Commander-in-Chief of the Bavarian Army. Like his compatriot Benjamin Franklin, he was a born experimenter, and had a keen desire to make his science practically useful to mankind. Mr. Mattieu Williams is not a mere theorizer. He has made practical experiments with regard to most of his hygienic theories, some of which he describes in a very amusing manner. He is entirely independent of Mrs. Grundy, and has little sympathy with those weaker brethren who study appearances. He recommends for men's shirts a loose cotton fabric, known to ladies and drapers as "oatmeal cloth." It thickens and becomes looser and more open in texture when washed. Starch is an abomination to him, as it deprives the shirt of its power of holding the air and keeps in the perspiration. But Mr. Williams' book must be read to be understood. It contains too much to attempt to give a summary of it. He has experimented with regard to the best type for reading without tiring the eyes, and in his preface gives the same page printed in ordinary thin-faced type, and in the thick *Clarendon* which he recommends. The thick-faced letters have the appearance of being larger, and it is not until you count the letters and note that the matter runs on the same, line for line, that you recognise that the only difference is in the thickness of the parts of the letters. The comparative luxury of reading a book printed in large type is generally costly, as the matter covers more paper in proportion to the size of the letters, but the thick-faced letters recommended by Mr. Williams save the eyes without adding any additional cost to printing a given quantity of matter.

Wild Nature won by Kindness. By Mrs. Brightwen. (T. Fisher Unwin; London, 1890.) Mrs. Brightwen's interesting reminiscences of animals and their ways, which have been published from time to time in the *Animal World*, have already made her known as a true lover and student of nature, and her book is likely to stimulate many readers to make experiment in the friendly association with, and close observation of, wild animals which Mrs. Brightwen describes with such evident pleasure. She says in her preface: "I often wished I could convey to others a little of the happiness I have enjoyed all through my life in the study of Natural History. During twenty years of variable health, the companionship of the animal world has been my constant solace and delight. . . . In the following chapters I shall try to tell my readers in a simple way about the many pleasant friendships I have had with animals, birds, and insects. . . . I use the word friendships advisedly, because truly to know and enjoy the society of a pet creature you must make it feel that you are, or wish to be, its friend, one to whom it can always look for food, shelter and solace; it must be at ease and at home with you before its instincts and curious ways will be shown. . . . I have always strongly maintained that the love of animated nature should be fostered far more than it usually is, especially in the minds of the young, and that we lose an immense amount of enjoyment by passing through life, as so many do, without a spark of interest in the marvellous world of nature." Here is a story of a young jay reared by Mrs. Brightwen: "In its babyhood my jay was much like other young things of its kind, always clamouring for food, and seeming to care for little else; but as he grew up he attached himself to me with a wonderful strength of affection which entirely reversed the order of things, for whenever I came into the room he was restless and unhappy until I came near enough for him to feed me. He would look carefully into his food-trough, and at last select what he thought the most tempting morsel, and then put it through the bars of his cage into my mouth. He would sometimes feed other people, but as a rule he disliked strangers; and I have known him even take water in his beak and squirt it at those who displeased him." On the whole, a jay is not a very desirable pet; he is restless in a cage, and too large to be quite convenient when loose in a room. Again, his great timidity is a drawback. Amongst the other animals with whom friendships were made were squirrels, mice, moles, snails, spiders, an Egyptian scarab-beetle. No more suitable book could be selected as a present for children in whom one desires to foster a love for animals. The hints with regard to the training of pets, and the choice of food for them, are excellent.

Nature and Woodcraft. By John Watson. (Walter Smith & Innes.) In his earlier volumes, Mr. Watson has already made his readers familiar with many scenes from the wild life of the feathery and furry inhabitants of Cumbria; in the present he gives further details in a similar happy vein, and we gladly recognise in it the same accuracy of observation, vividness of portraiture and freshness of style that imparted such a charm to his previous works. He is still the enthusiastic naturalist as well as sportsman, and his book breathes rather of the fresh open air of mountain and dale, forest and field, than of the close and stifling atmosphere of the study. As if to complete the picture of life in the land of fells and dales, he has added some exceedingly interesting sketches of the manners and customs of the dalesfolk, and the life they lived a generation or two ago, while they were still in their rural simplicity, and before they had succumbed to the influences of modern civilisation. No better historian could they have had than one so thoroughly acquainted with their present condition and the natural influences which have moulded their destiny.

Introduction to Fresh-Water Algæ. By M. C. Cooke, M.A., LL.D. (Kegan, Paul, French, Trübner & Co.) This cheap and compendious exposition of British Fresh-water Algæ, from the pen of so able an expositor as Dr. Cooke, will be a great boon to amateur microscopists. The pretty filaments of *Spirogyra*, with their coiled bands of green chlorophyll, the revolving globes of *Volvox*, and the graceful tufts of *Batrachospermum*, are always popular objects, and many a young microscopist has felt a desire to know something of the group to which these and a hundred other beautiful forms belong, but has been deterred from following up the study by the want of a suit-

able handbook within his means. To such Dr. Cooke's "Introduction" will prove of great service, and may be expected to become an incentive to the systematic study of these familiar but little understood plants. After some preliminary remarks on the collection and preservation of specimens, and on the methods of cell-increase in general, the marvellous facts of polymorphism are touched upon; the young beginner is thus taught at the outset the very needful lesson that he is not to imagine that difference of form necessarily involves difference of species, seeing that a species may appear, for example, at one period in its career in the form of isolated cells, at another as long threads, and again as broad fronds. The author then hurries on to the most essential part of his subject, that of reproduction. The extraordinary variety which the Algæ exhibit in the performance of this function constitutes one of the most fascinating elements in their study, and in consequence a great deal of space is here devoted to this complex and all-important theme. A sound foundation is thus laid in the only possible way for the thorough comprehension of the various green threads, cells, and other organisms that are of such constant occurrence in dippings from pond, ditch, and stream. The value of many species is exceedingly doubtful, and by no other means can their validity be tested than by the working out of life histories; hence the group affords endless scope for profitable, though at the same time difficult and laborious investigation, and the present manual will form an excellent introduction to larger treatises for all who care to undertake the study. The latter half of the book consists of a classification of all the British Fresh-water Algæ except the Desmids and Diatoms, with brief descriptions of the families, genera, and species. About 430 so-called species are thus enumerated, and as these are included in no less than 116 genera, the collector's labours in the identification of his miscellaneous "takes" would have been somewhat lessened if the author could have seen his way to the construction of a series of analytical tables as an aid in the discrimination of generic characteristics. Thirteen neatly-executed plates give an idea of the principal forms to be met with, and illustrate the details of about a quarter of the indigenous species.

Stray Feathers from Many Birds. By Charles Dixon. (W. H. Allen & Co.) Another addition to the already voluminous literature inspired by that perennial source of fascination and delight—bird-life. No "creatures that on earth do dwell" excercise such a powerful charm over lovers of nature as the feathered tribes, and yet, though the tale of their loves and sports and gambols and wars has been told again and again, each new observer finds something fresh to relate, and gives abundant evidence that the secrets of nature are practically inexhaustible. These "Leaves from a Naturalist's Note-Book" are a case in point. Amidst a good deal that is old, Mr. Dixon gives us much that is new, and even the old is pleasantly and freshly told. He begins by instructing his readers how to get into "nature's confidence," but it strikes us that this is not an art that can be taught. If a man has not an inborn sympathy with nature, he is not likely to be able to enter into its confidence by any rules of art; as with the true poet, the outdoor naturalist is born, not made. None the less, the unobservant are likely to increase their chances of interesting peeps into the domestic life of wild birds by due attention to Mr. Dixon's hints. The author's pictures are not all drawn from the homely surroundings of hedgerow, wood, and field; more lonely and less accessible situations are also laid under tribute. An early morning visit to the dreary waste of the shores of the Wash furnishes material for an interesting description of the curious method of bird-catching there adopted; long stretches of wide-meshed netting are supported on stakes driven upright into the ground, and the birds in their nightly migrations become entangled in the meshes and detained till the owner of the nets goes his usual round at dawn to see what the night has brought him. An invasion of the nurseries of the sea-birds on the Farne Islands, and a season of sport in Algeria, both reveal many a quaint and pleasant picture of domestic economy and every-day life in birdland, and an instructive chapter full of remarkable details gives much information on the subjects of moulting and seasonal variations of plumage. We are glad to read another protest against the enormous and indiscriminate slaughter of birds for the purposes of feminine adornment, although we regretfully confess our fear that such protests will be of little avail against the imperious calls of fashion. Half-a-dozen dainty illustrations by Whymper lend their aid in making this book a desirable addition to the library of every true disciple of nature.

Handbook of Field and General Ornithology: a Manual of the Structure and Classification of Birds. By Elliot Coues. 8vo., pp. 343, Illustrated. (London: Macmillan & Co.) All ornithologists who really desire to know something more about birds than the number, proportions, and colour of their feathers, the relative length and form of their beaks, and the structure of their feet and claws, will give a hearty welcome to the volume before us, which attempts to treat ornithology in a strictly scientific and thorough manner, and thus to raise it to the level of other branches of zoological science.

As we are informed in the publisher's preface, the work is an abridgment of the author's *Key to North American Birds*, which has for many years held a high position in the United States, the English edition containing such portions of the original work as are of more than local interest. The volume is illustrated by numerous figures in the text (some of which we are enabled, by the courtesy of the publishers, to reproduce), most of them apparently executed by one of the numerous typographical processes now coming so extensively into use. We regret, however, to see that some of these illustrations—more especially those on pp. 222 and 300—are so coarsely executed as to be repulsive to the artistic eye, and thus detract from the general smart appearance of the volume. The letterpress appears singularly free from misprints, although we may remark, in passing, the author does not appear to have been able to make up his mind whether to adopt the common spelling *anchylosis*, or the correct *ankylosis*.

The first eighty-seven pages of the volume are devoted to the collecting and preservation of birds, and the care necessary to be bestowed on a collection when made. All this is, no doubt, excellently well thought out, although not of sufficient general interest to require further notice here.

The second part commences with a general definition of birds, and a very brief sketch of some of the osteological features of the more important extinct types. In mentioning the close relationship of birds to reptiles (p. 95), the author is careful to observe that those reptiles which make the nearest approach to the avian type are the Dinosaurs, and not the Pterodactyles. The second section of this part, which is headed "Principles and Practice of Classification," contains some admirable observations on classification in general, and also on the importance of a classification being based on sound morphological principles. It likewise utters a word of warning as to the impossibility of taking any one single character as the

basis of classification of birds; as is abundantly proved by the number of totally different systems which have resulted from the adoption of this method by various writers. At the conclusion of this section the author mentions that the ornithological system is still in a transition state, and, apparently on this ground, he gives no system of avian classification at all—an omission which we regard as an

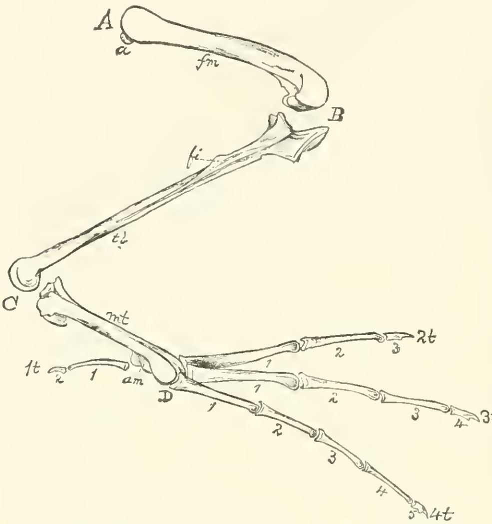


Fig. 1.—Bones of Right Leg of a Duck. *Fm*, femur; *a*, head of do.; *fi*, fibula; *tt*, tibia; *mt*, metatarsus; *1t*-*4t*, the four toes; 1–5, joints of do.; *A*, hip; *B*, knee; *C*, ankle; *D*, base of foot.

error of judgment. Indeed, when we refer to the alternative title of the volume, this omission forcibly reminds us of the celebrated chapter on Irish snakes.

In treating of the structure of birds, the author commences with the external characters, and then proceeds to the consideration of their internal anatomy. Feathers are described in full detail, with excellent illustrations, and especial attention is given to the important subjects of

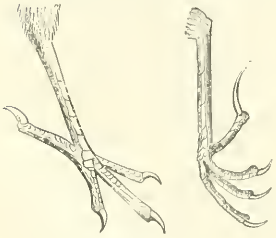


Fig. 2.—Incessorial Foot of a Passerine Bird.

Fig. 3.—Webbed Foot of a Pelican.

"pterylosis," the acquisition of the permanent plumage, and its periodical changes. In the description of the wings and feet we find lucid explanations given both of the exterior features and of the structure and mutual relations of the bones, the illustration on page 159 showing at a glance the homologies of the various bones of a bird's wing with those of the fore limbs of mammals. In the figure of the bones of the leg of a duck, which we reproduce, the author not only directs our attention to the individual bones, but also points out the joints corresponding to the human thigh, knee, and ankle. The absence of a series of free small bones in the ankle-joint of a bird is fully discussed; the complete union of the upper series of ankle-bones with the leg-bone, and of the lower ones with the three conjoint metatarsals being shown to be simply one step in advance of the reptilian type of structure, which differs from that of mammals by having the ankle-joint between the upper and lower rows of ankle-bones, instead of between the upper row and the leg-bone.

As their extreme importance demands, detailed and well illustrated descriptions are given of the characters of the various types of the feet of birds, pointing out the modifications adapted for the different duties they have to perform. It is thus pointed out that the feet of birds are chiefly modifications of three main types. Firstly, we have the "incessorial" type, as exemplified by the Passerines (Fig. 2), and aberrantly by the birds of prey. The second type is the "cursorial," as displayed in fowls and waders, while the last type is the swimming. The swimming type may present itself either as the fully-webbed foot of a Pelican (Fig. 52), or of a Duck, or in the curiously lobate foot of a Coot (Fig. 53), in which each joint of the toes has its own special flap of integument.

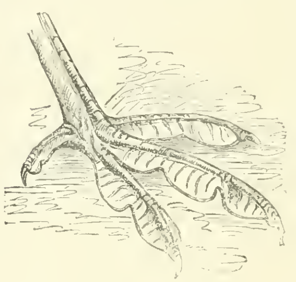


Fig. 4.—Lobate Foot of a Coot.

In treating of the general osteology, we notice that the author proposes the new term *sacrarium* for that part of the skeleton usually known as the sacrum, but of which only a small portion corresponds to the sacrum of a reptile. We are, however, doubtful whether this proposed change is of any advantage. The illustrations and descriptions of the base of the skull given in the succeeding pages will enable the student to readily comprehend the principles on which Prof. Huxley established his well-known classification of birds; but here again we regret the coarseness of the figures.

Of the soft inner parts the details given are generally more brief than those of other structures, this brevity being carried to an extreme in the case of the muscles; indeed, it appears hardly fair to the labours of the late Prof. Garrod to dismiss his elaborate work on the femoro-caudal muscles with the bare mention given on page 289. We are glad to see, however, fuller attention directed (page 293) to this writer's researches on the curious modifications assumed by the carotid arteries of the various groups of birds.

In endeavouring to place the popular study of birds on a sound anatomical basis, Professor Coues has done good service to science, and it may be confidently said of his work that it is the only one in the English language in which the student will find in a convenient and accessible form all details of both external and internal structure that are necessary to enable him to grasp the general principles of avian organisation. In conclusion, we venture to hope that the English edition of his work may attain a success like that which appears to have crowned its American forerunner.—R. L.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

RED, YELLOW, AND BLUE LIGHTNING.

To the Editor of Knowledge.

Dear Sir,—Perhaps the following description of three consecutive flashes of lightning seen by me during the storm of last Sunday may interest you. At about 3.30, while looking from a window due east, a flash occurred stretching upward far towards the zenith as a jagged *yellow* line. While looking with interest at the cumulus cloud from which it seemed to spring, a second flash occurred in the same region. It seemed in shape an oval yellow patch with a brilliant blue line down the centre. After an interval of a few seconds a third flash occurred, which seemed to start from the same spot in the sky and to stretch away horizontally to my right hand. It was of a bright red colour.—Yours truly,

28 August 1890. Frederic Pincott.

[Mr. Pincott's observation is interesting as tending to show that yellow, blue, and red flashes may all take place in the same region. It has been suggested that yellow and red flashes may be due to the ignition of dust in the lower atmosphere, while the blue flashes are due to discharges in the upper and purer air. It is possible that the differences of colour may be due to differences in the intensity of the discharge. There is a great difference in the spectra of flashes, some appearing to give a nearly continuous spectrum, while others give bright lines.—A. C. R.]

EXTRACT FROM A LETTER FROM PROF. BARNARD.

To the Editor of Knowledge.

You speak of the larger picture illustrating your article on the Milky Way as if it were an enlargement from my photograph. It is the *original size*. The others are *reductions*. E. E. Barnard.

To the Editor of Knowledge.

Sir,—In the May number of Knowledge in "A Gully in the Blue Mountains," C. Parkinson, F.G.S., appears the following: "Snakes are wonderfully few and far between . . . but under the improved medical treatment gained by experience I doubt if a necessarily deadly serpent (such as the cobra for instance) exists in Australia, unless it be in tropical Queensland." With reference to this statement, the writer must surely have heard of the "death-adder" of Australia (*death*, not *deaf*, as it is sometimes wrongly called). I think I can safely say that no *authentic* case has ever been known of recovery from the bite of this species. I have known a dog die from the bite in less than ten minutes.

Another paragraph in the article is as follows: "An old Australian informed me that all the best of the bird life finds a habitat on the inland side of the great Watershed, that is the Regent, Bower, and Rifle Birds." The old Australian who gave this information must have very little knowledge of his country. The home of the Regent, Rifle, Dragoon, Coachman, &c., birds is in the dense scrubs of the coast country; where I have seen the Regent birds was in the Bunya-Bunya scrubs of the Burnett district in Queensland, and I think, but cannot speak with certainty, that they are not found farther south than perhaps the Tweed River District of N. S. Wales. I am afraid that Mr. Parkinson must have obtained his information from one of those persons, who are to be found in Australia as elsewhere, one who, knowing some portion of Australia, considers that he is then entitled to speak "as one having authority" of the whole of this great island.

It is unfortunate that it is from these that visitors to Australia often obtain their information, and it is only after they have travelled in the country that they find that many years residence in one colony does not necessarily give a knowledge of the other colonies. The inhabitant of N. S. Wales, if he has never left his own colony, will know but little or nothing of Queensland, Western Australia, or the Northern Territory, and the resident of the western country is not the proper person from whom to obtain information of the coastal country.

It is in the scrubs of the coast country that the beautiful *fruit* pigeons, rivalling the parrot in their plumage, are to be found, not in the forest country of the interior. The Bower bird has a more extended range.

Sydney, N.S.W. Yours faithfully,
July 7, 1890. G. E. Favenc.

THE HEPTAGON.

To the Editor of Knowledge.

Sir,—In an article on the regular heptagon, in the February number of the *Philosophical Magazine* for 1864, Sir William Rowan Hamilton gives the solution of the problem how to construct a heptagon, which was proposed by Röber in the early part of the present century. Röber was an architect at Dresden, and his knowledge of mathematics was probably entirely empirical. He seems to have believed that his solution of this problem was mathematically accurate; and visiting Egypt at a period subsequent to the discovery of his method, he came to believe that the solution propounded by him was known to the ancient Egyptians. He believed that the architects and builders of the temple at Edfu, which is heptagonal, have left indications of an esoteric nature, in the stone (to be interpreted by the initiate in after ages), showing how they arrived at the construction of the heptagon; and that their method was identical with his own, which he had discovered independently. Sir William Hamilton points out that all the knowledge of ancient Egypt was in the hands of the priests, and considers that Röber's hypothesis is by no means untenable, and that the very method discovered, or rather re-discovered, by Röber may have been a secret in the keeping of the Egyptian priests, arrived at by them possibly "after centuries of tentation." Sir William, moreover, calls attention to the fact that although the Euclidian construction of the regular heptagon is still an unaccomplished problem, the mystery attaching to it in the age of ancient Egypt has long ceased to exist, and the heptagon simply ranks with an infinity of n-gons, each equally impossible to construct with mathematical accuracy. But the Egyptians associated a special sanctity with the mystical number seven, and the construction of the heptagon was to them what the *philosophers'* stone and the *Water of Life* were to the empirics of a later age.

Sir William Hamilton accompanies his article with a diagram illustrating Röber's method. The diagram is exceedingly complex, and to me it is not conceivable that two persons should arrive, independently of each other, at this same method. Nor do I think that any engraver, proposing to himself the task of describing with accuracy a regular heptagon, would choose Röber's method.

Sir William illustrates Röber's accuracy in the following way: He supposes seven tunnels bored through the earth in such a way that the seven tunnels represent the seven chords of the seven arcs of the circle formed by a section of the earth made at the equator and cut at right angles to the polar diameter, such circle having inscribed

in it a regular heptagon. He shows that although the mouth of the last tunnel does not emerge exactly at the mouth of the first tunnel, it nevertheless emerges within fifty feet of it.

While considering this matter I accidentally came across a solution of the problem, which, although it lacks mathematical accuracy, is marvellously near to the truth, while, at the same time, it is incomparably more simple in construction than Röber's method.

If the diameter of the circumscribed circle is unity and x is the side of an equilateral heptagon, we have

$$64x^6 - 112x^4 + 56x^2 = 7$$

from which we obtain for the value of x

$$\cdot 433{,}883{,}739{,}117{,}558{,}120{,}475 \ldots$$

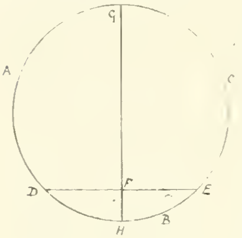
Now the fraction $\dfrac{63 - 9\sqrt{7}}{61 + 70\sqrt{3} - 65\sqrt{2}} = \cdot 433{,}883{,}738{,}080, \ldots$

and the accuracy is so great that if a regular inscribed heptagon were constructed in this manner, even in a circle a thousand miles in diameter, the error of each side (and the error, as will be observed, is in defect) would be *less than the fifteenth part of an inch.*

The simplest form of the above fraction, for construction, would be: $\dfrac{7 - \sqrt{7}}{6\frac{7}{9} + 7\frac{7}{9}\sqrt{3} - 7\frac{2}{9}\sqrt{2}}$

a fraction the parts of which are easily constructed.

Probably the easiest way to construct the square root of seven is the following:



ABC is any circle, the diameter of which is taken as the unit of rectilineal measurement.

Draw any diameter *GH*, and in it take

$$FH = \frac{GH}{8}$$

Through *F* draw the straight line *DFE* at right angles to *GH*, and terminated by the circumference of the circle at the points *D* and *E*.

Then $$DE = \frac{\sqrt{7}}{4}$$

I am, Sir, Your obedient servant,

August 23rd, 1890. GERARD DANIEL.

[There is a very old and comparatively simple way of approximately dividing a circle into seven parts, which De Morgan, in his *Notes on the History of Perspective*, published in the *Athenæum* (Sept. 12, 1863) says that he had traced through writers on perspective up to Albert Dürer, but that he could not trace it any further back. Albert Dürer assumed the side of a regular heptagon inscribed in a circle to be approximately equal to half the line which joins the two intersections of the circles in Euclid's first proposition. That is, if the diameter of the circle is 4, the side of the heptagon is approximately $\sqrt{3}$. De Morgan quaintly says of this: "It is too small, but anyone who would feel satisfied with £1 as composition for a debt of £1 0s. 0½d. ought to be a trifle better satisfied with Albert Dürer's heptagon." An error of less than one inch in forty feet is good enough for any ordinary drawing purposes. Mr. Daniel's approximation about corresponds to an error of a farthing in a million pounds, or to an error of an inch and a half in the meeting of Sir Wm. R. Hamilton's tunnels at the earth's equator.—A. C. R.]

To the Editor of KNOWLEDGE.

DEAR SIR,—The titles of Figs. 10 and 11 illustrating my paper on "Binary Stars of Short Period," in the August number of KNOWLEDGE, were by some oversight interchanged. Fig. 10 should be apparent orbit of 85 Pegasi, and Fig. 11 apparent orbit of ξ Scorpii. The diagrams themselves are correct.

Yours truly,

J. E. GORE.

NUMBERING THE DUST OF THE AIR.

By DR. McPHERSON, F.R.S.E.

ONE of the most remarkable contrivances of modern times enables us to count the minute inorganic dust-particles in the air. To Mr. John Aitken, an ingenious Scotch physicist, we owe this new method of research.

The bright motes that dance in the sunbeam seem beyond the power of computation, yet, by a marvel of mechanical ingenuity, Mr. Aitken has counted them. I shall never forget my rapt astonishment the day I first counted the dust in the Lecture Room of the Royal Society of Edinburgh, with his instrument and under his direction. The invisible particles in the air were brought within the range of vision, and even within the limit of easy enumeration.

The method of numbering the inorganic particles in the air depends upon a principle which was established by Mr. Aitken in his determination of the formation of fogs. He showed that without dust there could be no fogs, no mist, no rain. Without dust there would be only dew on the grass and road. This principle can be easily illustrated. Let common air be forced through a filter of cotton-wool into a glass receiver, from which the air has been exhausted; and let a glass receiver, filled with common air, be placed beside it. If steam be now admitted into the receivers, the one containing the common dusty air will soon be dense with fog, while the other containing the pure filtered air will remain perfectly clear. The particles of dust, then, are the free-surfaces which, in certain conditions, attract the water-vapour of the atmosphere to form fog. Invisible before, they are touched by the magic wand of a lowering temperature, and start into visible existence; the dust-particles are clothed all over with the moisture, and become fog-particles.

It then occurred to Mr. Aitken that if a small measured quantity of the common dust-impregnated air be mixed in a receiver with a large measured quantity of dustless air (which has been filtered through cotton-wool), the particles of dust would be some distance from each other; and, when these particles were made centres of condensation of vapour by lowering the pressure, fog-particles would be formed, which could be counted by means of a magnifying-glass. If, moreover, these particles fell from a certain height on a small, measured area, the number could be accurately ascertained. That is the secret!

Though Mr. Aitken has made great improvements on his instrument, the principle is the same, and the first apparatus is most easily explained without the assistance of diagrams. Into a common glass flask, of carafe-shape, and flat-bottomed, of 500 cubic centimetres (about 32 cubic inches) capacity, are poured 50 c.c. of distilled water. Through the air-tight stopper are passed two small tubes, at the end of one of which is attached (a little to the side of the orifice) a small square silver table of one square

centimetre in area. The flask is inverted, and the table is placed exactly one centimetre from the inverted bottom, so that the contents of air right above the table are one cubic centimetre. The observing table is divided by a fine instrument into 100 equal squares. The silver plate is then very highly polished; but the burnishing is done all in one direction, so that during the observations it appears dark when the fine mist-particles glisten opal-like with the reflected light, in order that they be the more easily numbered. The tube to which the silver mirror is attached, is connected with two stop-cocks, one of which can admit filtered air from one vessel, and the other can admit a small portion of the air to be examined. The other tube in the flask is connected with an air-pump of 150 c.c. capacity. Over the flask is placed a covering, coloured black in the inside. In the top of this cover is inserted a powerful magnifying-glass, through which the particles on the silver table can be easily counted. A little to the side of this magnifier is an opening in the cover, through which light is concentrated on the silver mirror.

To perform the experiment, the air in the flask is exhausted by the air-pump. The flask is then filled with the pure filtered air. By a nicely-designed apparatus, one exact cubic centimetre of the common dusty air is introduced. After one stroke of the air-pump, the air—mixture of 450 c.c. of filtered air, and 1 c.c. of common air—is made to occupy an additional space of 150 c.c.; and the exhaustion so produced chills the air, and causes condensation to take place on the dust particles. The observer, looking through the magnifying-glass upon the silver table, sees the mist-particles fall like a shower on the table. These particles last long enough to be numbered. The observer then counts the number on a single square in two or three places, and strikes an average. Suppose the average number upon one of the squares of the silver table were one, then on the table there would be 100; and the 100 particles of dust are those which floated in the cubic centimetre of mixed air right above the table. But as there are 600 c.c. of mixed air in the flask and the barrel, the number of dust particles in the whole is 600 times 100 =60,000; that is, there are 60,000 dust particles in one cubic centimetre of the common air which was introduced for examination. But as 1 c.c. is nearly equal to ·06 cubic inch, one cubic inch of that common air would contain no less than *one million* of dust particles.

Mr. Aitken has by this process counted $7\frac{1}{2}$ millions of dust-particles in a cubic inch of the ordinary air of Glasgow. I was with him when he was numbering the dust-particles in Edinburgh eighteen months ago. In the air outside the Royal Society rooms we counted four millions in the cubic inch. We counted the same number inside, at four feet from the floor; but near the ceiling, after the gas had been burning for some time, no less than 49 millions were counted in the cubic inch. After the two hours' meeting of the Fellows, the numbers increased to $6\frac{1}{2}$ millions and $57\frac{1}{2}$ millions respectively. He counted in a cubic inch of air immediately above a Bunsen flame no less than 489 millions of dust-particles. Of course, when the air is very dense with dust-particles, a fraction of a cubic centimetre of the air is introduced into the flask for the experiment; and, when the air contains fewer particles, more than one cubic centimetre is introduced.

The air of Colmonell, in Ayrshire, has been found to contain from 8,000 to 155,000 particles in the cubic inch. At Hyeres, in the south of France, he found from 50,000 to 400,000, according to the direction of the wind. At Lucerne, in Switzerland, the specimens of air tested were remarkably free from dust, some even as low as 3,500 in the cubic inch—the lowest observation he has yet made.

The question next arises as to whether 3,500 particles in the cubic inch of air is the lowest limit which the atmosphere ever attains to. Even away from the contaminations of smoky towns and villages, the air contains cosmic dust. There is always dust in the upper atmosphere, for without the dust no clouds could be formed; and of cosmic dust, there must always be a considerable quantity in the air produced by the waste from the millions of meteors that daily fall into it.

"The gay motes that people the sunbeams" are not, therefore, as Milton considered, "numberless." They have been enumerated with marvellous accuracy.

THE FACE OF THE SKY FOR OCTOBER.

By Herbert Sadler, F.R.A.S.

EVIDENCES of renewed solar activity are increasing, a very fine double group of spots being on the sun's disc at the time of writing these lines. Conveniently observable minima of Algol occur on the 9th at 12h. 43m. a.m., on the 11th at 9h. 31m. p.m., on the 14th at 6h. 23m. p.m., and on the 31st at 11h. 16m. p.m. Mercury is a morning star throughout October, and is very favourably situated for observation. On the 1st he rises at 5h. 49m. a.m. with a southern declination of 2° 53′, and an apparent diameter of 10″. On the 15th he rises at 4h. 38m. a.m., or 1h. 47m. before the sun, with a southern declination of 0° 17′, and an apparent diameter of $6\frac{1}{2}$″. On the 31st he rises at 5h. 50m. p.m., or 1h. 4m. before the sun, with a southern declination of 9° 55′, and an apparent diameter of 5″. He is stationary on the 8th, and at his greatest western elongation (18°) on the 15th, and will appear at his brightest on the mornings of the 21st to 26th. He is in Virgo throughout the month, but does not approach any conspicuous star.

Venus is an evening star, but is badly situated for observation in these latitudes owing to her great southern declination. She sets on the 1st at 6h. 42m. p.m., 1h. 5m. after sunset, with a southern declination of 23°, and an apparent diameter of 27″. On the 31st she sets at 5h. 38m. p.m., 1h. 4m. after sunset, with a southern declination of 27° 57′, and an apparent diameter of 42″. She is at her greatest brightness on the 30th, but, as she is almost invisible in the greater part of England, no further details need be given. During the month she passes from Libra into Scorpio. Mars is visible, but at a great disadvantage, as an evening star. He sets on the 1st at 9h. 16m. p.m., with a southern declination of 25° 52′, and an apparent diameter of $9\frac{1}{4}$″. On the 31st he sets at 9h. 8m. p.m., with a southern declination of 22° 56′, and an apparent diameter of $7\frac{3}{4}$″. On the 31st his brightness is only one-sixth of what it was at opposition; and in view of his increasingly diminishing diameter, we shall not continue our ephemeris of him after the present month. He is in Sagittarius during October, but does not approach any conspicuous star very closely.

Jupiter is an evening star, setting on the 1st at 11h. 50m. p.m., with a southern declination of 20° 25′, and an apparent equatorial diameter of $42\frac{1}{2}$″. On the 31st he sets at 10h. 2m. p.m., with a southern declination of 20° 0′, and an apparent equatorial diameter of $38\frac{3}{4}$″. He is in quadrature with the sun on the 27th. The following phenomena of the satellites occur while the planet is more than 8° above, and the sun more than 8° below, the horizon. A transit ingress of the shadow of the third satellite at 7h. 12m. p.m. on the 1st. A transit egress of the shadow of the fourth satellite at 6h. 30m. p.m. on the

3rd; a transit ingress of the first satellite at 8h. 41m. P.M.; and a transit ingress of its shadow at 9h. 56m. P.M. An eclipse reappearance of the first satellite at 9h. 34m. 26s. P.M. on the 4th. A transit egress of the shadow of the first satellite at 6h. 45m. P.M. on the 5th. An occultation disappearance of the second satellite at 9h. 44m. P.M. on the 8th. A transit egress of the third satellite at 9h. 44m. P.M. on the 8th. A transit egress of the shadow of the second satellite at 8h. 44m. P.M. on the 9th. An occultation disappearance of the first satellite at 7h. 54m. P.M. on the 11th, and an eclipse disappearance of the fourth satellite at 9h. 47m. 49s. P.M. A transit ingress of the shadow of the first satellite at 6h. 20m. P.M. on the 12th; a transit egress of the satellite itself at 7h. 22m. P.M., and of its shadow at 8h. 41m. P.M. A transit ingress of the shadow of the second satellite at 8h. 25m. P.M. on the 16th, and a transit egress of the satellite itself at 8h. 39m. P.M. A transit ingress of the first satellite at 6h. 56m. P.M. on the 19th; a transit ingress of the fourth satellite at 7h. 35m. P.M.; a transit ingress of the shadow of the first satellite at 8h. 16m. P.M.; an eclipse reappearance of the third satellite at 8h. 57m. 32s. P.M.; a transit egress of the first satellite at 9h. 16m. P.M. Thus, for more than an hour on the evening of the 19th only one satellite, the second, will be visible. An eclipse reappearance of the first satellite at 7h. 54m. 2s. P.M. on the 20th. A transit ingress of the second satellite at 8h. 19m. P.M. on the 23rd. An eclipse reappearance of the second satellite at 8h. 7m. 36s. P.M. on the 25th. An occultation reappearance of the third satellite at 7h. 38m. P.M. on the 26th, and a transit ingress of the first satellite at 8h. 50m. P.M. An occultation disappearance of the first satellite at 6h. 11m. P.M. on the 27th. A transit egress of the first satellite at 5h. 41m. P.M. on the 28th; a transit egress of its shadow at 7h. 1m. P.M.; and an eclipse reappearance of the fourth satellite at 8h. 41m. 40s. P.M. on the 28th. On the evening of the 31st a $9\frac{1}{4}$ magnitude star will be very near the planet; it will be in conjunction with the centre at about 9h. 20m. P.M., at about 5″ south of the planet's southern limb. Jupiter is in Capricornus during the month, but does not approach any naked-eye star.

Saturn is, for the purposes of the amateur observer, invisible during October; Uranus is in conjunction with the sun on the 20th. Neptune is an evening star, rising on the 1st at 7h. 46m. P.M., with a northern declination of 19° 49′, and an apparent diameter of $2\frac{1}{2}$″. On the 31st he rises at 5h. 46m. P.M., with a northern declination of 19° 42′. He describes an excessively short retrograde arc to the N.N.W. of ε Tauri during the month (*cf.* "Face of the Sky" for September).

October is rather a favourable month for observations of shooting stars, the most marked shower being that of the Orionids, from the 17th to the 20th of the month, the radiant point of which is situated in vi.h. 0m. R.A. +15° declination. The radiant point rises at the date named at about 8h. 45m. P.M., and sets shortly after 4h. A.M.

The moon enters her last quarter at 8h. 23m. P.M. on the 5th; is new at 11h. 5m. P.M. on the 13th; enters her first quarter at 5h. 36m. A.M. on the 21st, and is full at 11h. 42m P.M. on the 27th. The 5th magnitude star 38 Arietis will disappear at 1h. 4m. A.M. on the 1st at an angle of 172° from the vertex, and reappear at 1h. 35m. A.M. at an angle of 230° from the vertex. At 9h. 46m. P.M. on the 2nd the planet Neptune (resembling an 8th magnitude star) will disappear at an angle of 82° from the vertex, and reappear at 10h. 42m. P.M. at an angle of 238° from the vertex. The $5\frac{1}{2}$ magnitude star 48 Geminorum will disappear at 11h. 28m. P.M. on the 5th at an angle of 48° from the vertex, and reappear at 0h. 26m. A.M. on the 6th at an angle of 241° from the vertex. The $7\frac{1}{2}$ magnitude star B.A.C. 7197 will disappear at 9h. 35m. P.M. on the 21st at an angle of 143° from the vertex, and reappear at 10h. 39m. P.M. (the moon having set at Greenwich at the time) at an angle of 315° from the vertex. The 6th magnitude star B.A.C. 7550 will disappear at 7h. 3m. P.M. on the 22nd at an angle of 95° from the vertex, and reappear at 8h. 14m. P.M. at an angle of 313° from the vertex. The $5\frac{1}{2}$ magnitude star τ^1 Aquarii will disappear at 11h. 28m. P.M. on the 23rd at an angle of 92° from the vertex, and reappear at five minutes after midnight at an angle of 23° from the vertex. This star has a 9th magnitude companion of an amethyst hue at 31″ distance. At 0h. 28m. A.M. on the 23rd the 4th magnitude star τ^2 Aquarii will disappear at an angle of 144° from the vertex, and reappear at 1h. 26m. A.M. (the moon being in the act of setting at the time) at an angle of 340° from the vertex. This star has a distant blue 9th magnitude companion at 132″ distance. On the 27th at 6h. 28m. P.M. the 6th magnitude star 64 Ceti will disappear at an angle of 86° from the vertex, and reappear at 7h. 26m. P.M. at an angle of 252° from the vertex; and the $4\frac{1}{2}$ magnitude star ξ^1 Ceti will disappear at 7h. 22m. P.M. at an angle of 100° from the vertex, and reappear at 8h. 21m. P.M. at an angle of 247° from the vertex, On the 28th the $5\frac{1}{2}$ magnitude star ξ Arietis will disappear at 2h. 12m. A.M. at an angle of 100° from the vertex, and reappear at 3h. 36m. A.M. at an angle of 296° from the vertex; and the 7th magnitude star B.A.C. 755 will disappear at 3h. 29m. A.M. at an angle of 132° from the vertex, and reappear at 4h. 30m. A.M. at an angle of 349° from the vertex. The 6th magnitude star B.A.C. 1240 will disappear at 7h. 59m. P.M. on the 29th at an angle of 6° from the vertex, and reappear at 8h. 21m. P.M. at an angle of 319° from the vertex. At 1h. 8m. A.M. on the 30th the 6th magnitude star ω^1 Tauri will disappear at an angle of 189° from the vertex, and reappear at 1h. 18m. A.M. at an angle of 208° from the vertex.

Whist Column.

By W. Montagu Gattie.

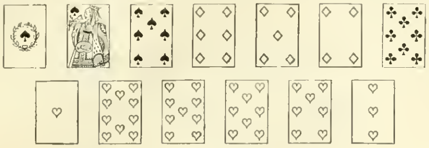
There are few mistakes more common with beginners than the play of the king to the first round of a suit by the second hand when holding only one other card of that suit, the idea being that the king in this way takes the best chance of escaping the ace. Beyond the fact that the leader probably has at least four cards of the suit, there is really no more reason for supposing that the ace is with him, when a small card is led, than that one of the other players has it; and it should be borne in mind that the ace is usually led at once from a suit of five cards or more. By parting with his king the second player not only deprives his side of the advantage of the fall of the trick (*e.g.* the third player's queen may fall to the fourth player's ace), but he abandons all chance of acquiring command of the adverse suit, and at the same time makes an unmistakable declaration of his own weakness, enabling the leader to finesse as deeply as he pleases when the suit is returned.

In the case of trumps it is sometimes right to put in the king; but in plain suits it is a very safe rule that a small card led should always be passed.

A somewhat unique illustration is furnished by the following hand, which is taken from actual play, and which

is also interesting on account of the skill with which the player whose hand is exposed profited by his opponent's mistake.

Hand No. 14.



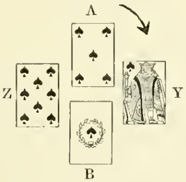
B's Hand.

Score—AB, 0; YZ, 4.

Z turns up the ace of diamonds.

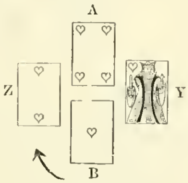
Note.—A and B are partners against Y and Z. A has the first lead; Z is the dealer. The card of the leader to each trick is indicated by an arrow.

Trick 1.



Tricks—AB, 1; YZ, 0.

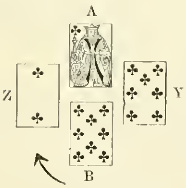
Trick 2.



Tricks—AB, 2; YZ, 0.

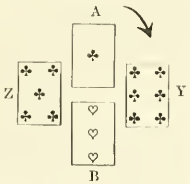
Note.—Y having played the king of spades second in hand, probably has no more of that suit. B therefore prefers to open his own suit instead of returning the best spade at once.

Trick 3.



Tricks—AB, 3; YZ, 0.

Trick 4.

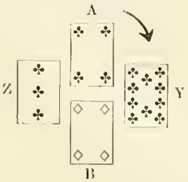


Tricks—AB, 4; YZ, 0.

Notes.—*Trick* 3.—Y being short in two suits, probably has strength in trumps. Looking to the state of the score and to his own weakness in trumps, B leads his single club.

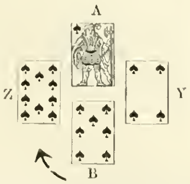
Trick 4.—Z "echoes" to his partner's "call."

Trick 5.



Tricks—AB, 5; YZ, 0.

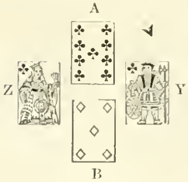
Trick 6.



Tricks—AB, 6; YZ, 0.

Note.—In view of the adverse "call" and "echo," A can scarcely have more than one trump. Moreover, Y has either the best heart or no more. The only chance, therefore, is to lead a losing spade, in the hope that Y may have another, and that A may be able to win the trick and lead another club.

Trick 7.



Tricks—AB, 7; YZ, 0.

The six remaining tricks are won by YZ; and AB score the odd trick, and save the game.

A's Hand.	B's Hand.
	D.—6, 5, 4.
C.—Ace, Kg, 9, 4.	C.—8.
H.—Kn, 5, 4.	H.—Ace, 10, 9, 8, 7, 3.
S.—Kn, 9, 6, 5, 3, 2.	S.—Ace, Qn, 7.
Y's Hand.	**Z's Hand.**
D,—Kg, Qn, Kn, 10, 9, 2.	D.—Ace, 8, 7, 3.
C.—Kn, 10, 7, 6.	C.—Qn, 5, 3, 2.
H.—Kg.	H.—Qn, 6, 2.
S.—Kg, 4.	S.—10, 8.

Remarks.—Y plays his king at Trick 1, because he is anxious to get the lead and open trumps. He pays dearly for his impatience. At one time there were whist players who advocated this play of the king under certain circumstances; and, in calculating the probabilities of success, the case in which the third player holds ace, queen, has sometimes been taken as one in which "it makes no difference" which course is adopted, since the king must fall either way. The foregoing hand furnishes an instance to the contrary. Had Y held up his king, Y would have finessed the queen, of course; but nothing could then have prevented YZ from making the game.

At the same time, the play of A and B illustrates the maxim that every rule admits of exceptions. B declines at Trick 2 to lead out the master-card of his partner's suit, and leads a "singleton" at Trick 3, besides disregarding the familiar precept "Avoid changing suits"; and A, without a trump in his hand, deliberately forces his partner twice. Both players grasp the situation and adopt the only line of play that can possibly save the game.

Chess Column.

By I. Gunsberg.

The following game was played between Messrs. Gunsberg and Mason, at the International Chess Tournament, at Manchester, on September 4th, 1890:—

	White. Mason.	Black. Gunsberg.		White. Mason.	Black. Gunsberg.
1.	P to K4	P to K4	20.	B to B3	B to Q4 (*f*)
2.	K to KB3	Kt to QB3	21.	QR to Ksq	B×P
3.	B to Kt5	Kt to B3	22.	Q to K7	Q×Q
4.	P to Q3	P to Q3	23.	R×Q	Kt to Q4 (*h*)
5.	Kt to B3	B to K2 (*a*)	24.	R to Q7 (*i*)	B to B5
6.	Kt to K2	B to Q2 (*b*)	25.	R to Ksq	B to R3 (*j*)
7.	Kt to Kt3	Castles	26.	B to R5	B to Bsq
8	Castles	Kt to Ksq	27.	R×P	Kt×R
9.	B × Kt	P×B	28.	B×Kt	R×P (*k*)
10.	P to Q4	P×P	29.	B×P	R to B3
11.	Kt×P	B to B3	30.	B to B5	R to K3 (?)
12.	P to QB3 (*c*)	B×Kt	31.	Kt to K5	P to R4
13.	P×B	P to KB4	32.	R to Rsq	B to Kt2
14.	P to KB4 (*d*)	P×P	33.	P to R3	K to R2
15.	Kt×P	B to B4	34.	R to R3	P to R5 (*l*)
16.	Kt to Kt5 (*e*)	Q to Q2	35.	K to R2	B to Bsq
17.	B to Q2	P to KR3	36.	P to QKt3	R to Ktsq (*m*)
18.	Kt to B3	B to K5	37.	P×P	R to Kt7
19.	Q to K2	Kt to B3	38.	R to KKt3	B to R3 (*n*)

White. Mason.	Black. Gunsberg.	White. Mason.	Black. Gunsberg.
39. B to B8 (*o*)	R to Kt2	56. B to B5	R to Kt7 (ch)
40. B to B5	R to B3	57. K to Kt3	R to R7
41. P to R5	R to Kt7	58. B to Kt6	R to R8
42. Kt to Q3	B×Kt (*p*)	59. K to B2	R to R7 (ch)
43. R×B	R to R7	60. K to Kt3	R to R8
44. B to Kt6 (*q*)	K to Ktsq (*r*)	61. K to B2	R to R6
45. R to KKt3	K to B2	62. K to Kt2	K to B5 (*x*)
46. K to Ktsq	P to R4	63. K to B2	R to R7 (ch)
47. K to R2	R to Kt3 (*s*)	64. K to Ksq	K×P
48. B to Q8	R×R	65. K to Qsq	K to B6
49. K×R	K to K3	66. K to Bsq	P to Kt5
50. K to B3	K to Q4	67. K to Ktsq	R to R5
51. B to Kt6	P to Kt4! (*t*)	68. K to Kt2	P to Kt6
52. P to Kt4 (*u*)	R to R6 (ch) (*v*)	69. K to Kt3 (*y*)	R×P
53. K to Kt2	P×P	70. B×R	P to Kt7
54. P×P	K to K5	71. P to Q5	P to B4 (*z*)
55. K to B2	R to QKt6 (*w*)	Resigns.	

Notes.

(*a*) Or P to KKt3 followed by B to Kt2, &c.

(*b*) A waiting move, to avoid castling as long as White can advance his KRP and KKtP.

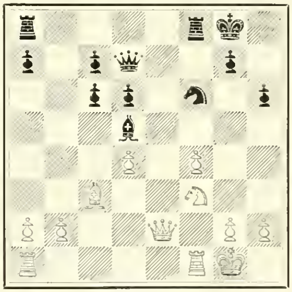
(*c*) KKt to B5 would have prevented the intended advance of Black's KBP whereby he obtained an open game.

(*d*) 14. P to K5 would be answered by P to B5, but 14. P to B3 should result in a satisfactory game for White.

(*e*) Loses time, as White seeks to retire his Knight to B3, which is, however, not a favourable square in view of the possibility of Black establishing his Bishop on Q4.

Position at Black's 20th Move.

Black.—Gunsberg.



White.—Mason.

(*f*) Black has now an excellent game, and is ready to pursue the attack with R to Ksq, Kt to K5, Q to Kt5, and other moves which should tend to his advantage.

(*g*) White probably felt that he must make some effort to forestall the impending advance, and, moreover, if Black takes the RP his own QRP will in course of time become untenable. White also perhaps put an undue value on the move of Q to K7. However that may be, the sacrifice of the Pawn and White's subsequent play was a serious error of judgment.

(*h*) This move gives Black a winning game.

(*i*) There is no escape from here for the Rook.

(*j*) It seemed the most natural thing to do, to win the exchange by playing B to R3 and B to Bsq, but R×P ought to have given Black a far easier game to play; he would have been two Pawns to the good and would still threaten to win the exchange, or simplify matters by playing R to B2.

(*k*) It was difficult to decide between this move and P to Q4. The latter move was probably better.

(*l*) Black has a very restricted position and must endeavour to bring his pieces into play by abandoning this Pawn, the only question being as to the most advantageous way of doing so.

(*m*) Black has at last managed, at the cost of a Pawn, to struggle into a playable position.

(*n*) If Black plays R to R7, White could continue with 39. B to B8, threatening complications which it is as well to avoid.

(*o*) This is now loss of time, as it will enable Black to play R to B3, bringing also his second Rook into play.

(*p*) Kt to Kt4 might become troublesome. By taking this Knight Black, with a draw in hand, has still some winning chances.

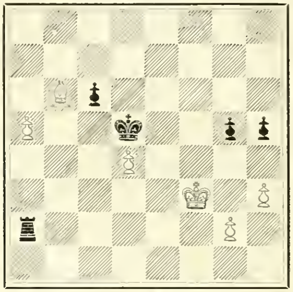
(*q*) If R to R3, Black replies with R(B3)B7.

(*r*) An attempt to gain time. An exchange of Rooks would be favourable for Black. This he could now bring about by playing R to Kt3, compelling R to Kt3 by White; but Black endeavours to gain time, and play R to Kt3 when his K is on B2, because his advantage would be increased if he can bring his King into the middle of the board earlier than White.

(*s*) Black has gained the time he was striving for.

Position after Black's 51st Move.

Black.—Gunsberg.



White.—Mason.

(*t*) It is not by any means clear whether now there is any way for Black to force a win. There are two ideas worth fighting for, which, however, can only be vaguely given in outline, namely, to drive the King back sufficiently far to enable Black to play K to Kt4 followed by R × RP, or to advance the Kt's pawn to Kt6.

(*u*) A mistake, which costs the game.

(*v*) Black could also have played P to R5, followed by R to R7.

(*w*) Too much caution. Black is endeavouring to drive the King back still farther, but K to B5 would have won.

(*x*) Black has gained one more move on White through the manœuvres of the last few moves; on his 55th move, when Black could have played K to B5, the White King stood on B2.

(*y*) P to Q5 was his only way of prolonging the game.

(*z*) The last move sufficiently indicates the cautious manner in which Black was playing this ending, in which he never lost his advantage; and although it is possible that White missed some drawing chances, still the play from the 37th move is an instructive example of various phases of end-game play, illustrating the power of a Rook when in the seventh file, and the value of gaining time.

J. Wall.—The ending as sent by you seems like an impossible position, as White's Pawns could hardly have got placed like that, as if 1. P to Q4, P×P, Black could win; but if P to Q4, P to B5, B to R4, P to Kt4, White has an advantage.

Black Combe.—I shall act upon your suggestion.

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CONTENTS.

GIANT LAND REPTILES.

BY R. LYDEKKER, B.A.CANTAB.

(*Continued from page* 225.)

THE third great group of Giant Land Reptiles was first definitely brought under the notice of the scientific world by the late Dean Buckland, the celebrated Professor of Geology in the University of Oxford, as far back as the year 1824. The Professor had observed that in the Stonesfield slate of Oxfordshire, to which allusion has already been made in the first part of this article, there were not uncommonly found teeth of the peculiar type of the one shown in woodcut 4; although many of them were of considerably larger dimension than the figured specimen. It will be seen from the figure that this type of tooth (of which only the crown or exposed portion is represented) differs very widely indeed from the teeth of the Iguanodon and Hoplosaur, of which figures were given in the preceding number of KNOWLEDGE. Thus the crown of this tooth is much flattened from side to side, with sharp cutting fore-and-aft edges, of which the front one is highly convex, while the hinder one is either nearly straight or somewhat concave. Moreover, one or both of these cutting-edges were serrated like a saw, thus indicating that these formidable teeth were adapted for tearing and rending flesh. This led Dr. Buckland to conclude that the old Stonesfield reptile, to which these teeth once belonged, must have been of carnivorous habits; and since the bones found in the same deposits indicated a creature of comparatively huge dimensions, he proposed that it should be known as the Megalosaur, or Great Reptile. Since, however, the thigh-bone of the Megalosaur does not exceed a yard in length, it is obvious that the creature was vastly inferior in point of size to the Hoplosaur and its kindred.

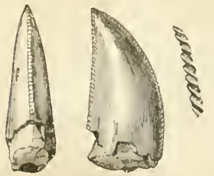


FIG. 4.—EDGE AND SIDE VIEWS OF THE TOOTH OF A MEGALOSAURIAN REPTILE, WITH PART OF THE SERRATIONS ENLARGED.

Similar teeth were subsequently found by Dr. Mantell in the much higher Wealden beds; and by discoveries afterwards made both in Europe and the United States, it was eventually found that the Megalosaur was merely one representative of a group of Giant Land Reptiles characterised, among other peculiarities, by the possession of teeth of the type described above, and also by having sharply curved claws adapted to aid these teeth in seizing and destroying living prey. While, therefore, the Iguanodons and the Hoplosaurs of the secondary period may be compared to the herbivorous elephants and hippopotami of the present fauna of the globe, the place of the lions and tigers of to-day was occupied in the same early epoch by the Megalosaurs.

Although these Megalosaurs walked upright, like the Iguanodons, which they also resembled in having hollow limb-bones, there is a very important difference between these two groups of reptiles in regard to that part of the skeleton which includes the haunch-bones, and is technically known as the *pelvis* (from the Latin word for a basin, in allusion to the basin-like shape of the human pelvis). Now since it is to a great extent from the structure of the pelvis that the affinity between Giant Reptiles and Birds has been proved to exist, it is worth while to pay some attention to this point; although the reader must make up his mind not to be frightened by the unavoidable use of a certain number of technical terms for bones which have no vernacular name. If, then, the reader will direct his attention to Fig. 5, which represents one side of the pelvis

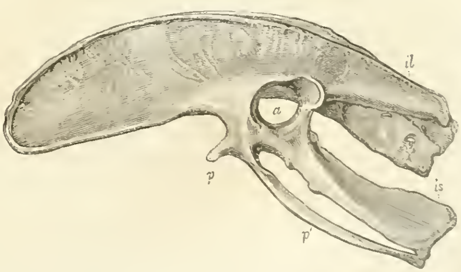


FIG. 5.—LEFT SIDE OF THE PELVIS OF THE KIWI. *il*, haunch-bone or ilium; *p*, *p*, pubis; *is*, ischium; *a*, cup for head of thigh-bone. (After Marsh.)

of the remarkable New Zealand wingless bird known as the Kiwi or Apteryx, he will observe that the haunch-bone extends as a deep vertical plate a long distance in advance of the cup for the reception of the head of the thigh-bone. He will also see that the inferior portion of the pelvis is composed of two bars of bone respectively known as the pubis and ischium, lying nearly parallel to one another and directed behind the aforesaid cup for the thigh-bone. The pubis, or more anterior bone, also gives off a small process (*p*) projecting towards the head of the animal from

its upper end. Now this type of pelvis is found, at the present day, only among birds, that of lizards and crocodiles being quite different. If, however, we turn to the figure of the skeleton of the Iguanodon given in the first half of this article, we shall find, as briefly mentioned there, that the pubis and ischium (seen to the right of the leg) run parallel to one another, and are directed backwards after the fashion obtaining in birds. It is true, indeed, that in the Iguanodon the pubis is shorter than the ischium; and it also gives off a large anterior plate (seen to the left of the leg) corresponding to the small process p^1 in the pelvis of the Kiwi. These, however, are but minor points of difference which do not affect the fundamental

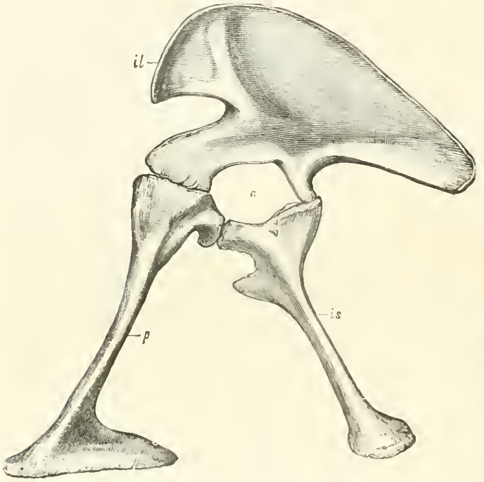


Fig. 6.—Left Side of the Pelvis of the Megalosaur. $\frac{1}{12}$th natural size. Letters as in Fig. 5. (After Marsh).

identity of plan. Again, the haunch-bone of the Iguanodon extends far in advance of the cup for the head of the thigh-bone, and thus once more follows (or, as we should rather say, leads) the bird fashion. These peculiarities in the structure of the pelvis of the Iguanodon, coupled with other features in its organisation, ought to leave no doubt, in the minds of all unprejudiced observers who hold the doctrine of evolution, that there is some direct affinity between the extinct Giant Reptiles and the modern wingless birds.

Turning now to the pelvis of the Megalosaur, of which a greatly reduced representation is given in Fig. 6, it will at once be apparent that we have to do with a widely different type of structure. Thus we notice, in the first place, that the haunch-bone extends but a comparatively short distance in front of the cup for the head of the thigh-bone. Then, again,—and this is by far the most important feature the pubis is directed forwards instead of backwards, and thus, instead of lying parallel with the ischium, is placed at a very open angle to that bone. This form of pelvis, although differing in some details, is, indeed, of the general type of that obtaining in modern crocodiles; and thus serves to show that in this respect the Megalosaur (and likewise the Hoplosaur) were more nearly related to ordinary reptiles, and less closely to birds, than is the case with the Iguanodon.

If, however, we were led to conclude from the foregoing facts that the Megalosaur presented no closer indications of affinity with birds than is exhibited by modern crocodiles, we should be grievously in error; for not only does it exhibit such a relationship, but exhibits it in a manner which is not displayed by the Iguanodon. In this respect we have, therefore, an excellent illustration of that extreme complexity in the mutual relationships of extinct animals, which should serve as a warning against hasty conclusions as to any one extinct type having been the actual ancestor of an existing creature.

The relationship of the Megalosaur to birds is best exemplified by certain features in the form and connection of the bones of the lower leg and ankle, in attempting to explain which we must again crave the reader's pardon for the introduction of a certain number of unavoidable technicalities.

Most of us are probably aware that our own ankle consists of two rows of small bones, of which the upper row includes the heel-bone, and the ankle-bone (corresponding to the well known "huckle-bone" of a leg of mutton); while the lower row has four smaller bones. Now in moving the foot on the leg, as in the action of walking, it is evident to all of us that the joint is situated between the two long-bones of the leg and the upper row of the ankle, *i.e.* the heel-bone and ankle-bone. In a crocodile, on the contrary, the ankle joint occurs between the upper and the lower rows of the ankle, so that the heel-bone and the ankle-bone move with the leg-bones. In a bird there is yet one step further on this, for not only does the movable joint occur between the upper and the lower rows of the ankle, but the ankle-bone and the heel-bone are respectively united with the two long-bones of the leg, so as to form practically single bones; while the bones of the lower row of the ankle similarly unite with the long-bone supporting the toes, so as to form that single slender bone, with three pulley-like lower surfaces, with which we are all familiar in the leg of a fowl. An adult bird, therefore, while having an ankle-joint, has no separate ankle-bone.* In a young bird, however, as we may see for ourselves in the case of a young fowl on our dinner-table, the lower end of the so-called "drumstick," or main bone of the leg, is incompletely united to the bone itself, so that it can be readily detached; this detachable portion being, in fact, the bird's true ankle-bone.

Fig. 7.—The Lower End of the Leg-bone of the Megalosaur, with the Ankle-bone attached to it. (After Gaudry.)

Now in the crocodile, as we have already mentioned, the ankle-bone, although moving with the leg-bone, remains perfectly separate therefrom; but in the Megalosaur we find a condition exactly intermediate between that obtaining in the crocodile and the adult bird. This will be apparent from Fig. 7, where we see the lower end of the leg-bone of the Megalosaur with the ankle-bone closely applied to it, and probably immovably united thereto during life by cartilage. This condition is, indeed, precisely similar to that which exists in the young fowl; and thus we have, so to speak, displayed before us the actual manner in which the leg of a reptile has become converted into that of a bird, the young bird carrying with it the history of its origin fully apparent to all who will but read Nature's

* The reader will be assisted in this description by turning to the figure of the bones of a bird's leg, given on page 236 of the preceding number of Knowledge.

secrets aright. When, however, we make this statement we by no means intend to imply that the Megalosaur or any of its immediate kindred were the direct ancestors of birds, but only that they were more or less closely allied to such unknown ancestral types.

There are almost equally remarkable resemblances in the structure of other parts of the leg of the Megalosaur to that of birds, but the feature indicated is amply sufficient for our present purpose.

The group of which the Megalosaur is our typical example is a large one, and contains some species with a thigh-bone upwards of a yard in length, down to tiny little creatures scarcely as large as a rabbit. These reptiles were widely spread over nearly the whole globe; their remains having been obtained from the secondary rocks of Europe, India, South Africa, North America, and even as far north as Behring Strait. Some of the smaller species, like those found in the lithographic limestones of the Continent and in the United States, probably took considerable leaps with their long hind legs, and must thus have resembled the smaller kangaroos of Australia.

Briefly summing up the result of the foregoing observations, we find that the Giant Land Reptiles may be divided into three great primary groups presenting the following distinctive features. In the first group, as represented by the Iguanodon, the teeth were adapted for grinding, and had flattened crowns, ornamented with ridges on the outer side; the limb-bones were hollow; the pelvis was bird-like; and the mode of progression was bipedal. In the second group, as exemplified by the Hoplosaur, we have nearly or quite the largest known land animals; their teeth were spoon-like, and adapted for vegetable food; the limb-bones were solid throughout; the pelvis was not very unlike that of a crocodile; and the mode of progression was quadrupedal. Finally, in the third group, of which we took the Megalosaur as our type, the teeth and claws were adapted for capturing and devouring living prey; and although the pelvis approximated to the crocodilian plan, yet in the structure of the leg and ankle these reptiles (in which the limb-bones were hollow) made a closer approximation to birds than is presented even by the Iguanodon.

The above-mentioned remarkable variations of structure presented by the members of the three foregoing groups might well have been supposed to exhaust the peculiarities displayed by the Giant Land Reptiles. In the very topmost beds of the secondary rocks of the United States there occur, however, the remains of another group of these creatures, which appear to indicate a special modification of the original stock from which the Iguanodons took their origin, and which present some of the most bizarre and strange creatures yet revealed to our astonished gaze in a country where fossil animals appear to have run riot as regards strangeness. The occurrence of these creatures in the topmost cretaceous rocks, at a period just before the whole group of Giant Reptiles became extinct for ever, is like the final "flare-up" at the close of a display of fireworks, and suggests to us that the extreme specialisation to which these creatures had finally attained rendered them unsuitable for the wear and tear of life, and thus conduced to their final extinction.

The reptiles forming this group or sub-group are collectively known as the Armoured and the Horned Dinosaurs. Their pelvis is a modification of that of the Iguanodon, usually exhibiting the backward direction of the pubis and ischium; but the limb-bones were solid, and either the body was covered with huge bony plates and spines, or long horn-cores, like those of the oxen, were present on the skull.

The Armoured Dinosaurs were first made known to us by more or less imperfect skeletons discovered in the Lias, Kimeridge Clay, and Wealden formations of England. One of the best known of these reptiles is the so-called Stegosaur, of which a considerable portion of the skeleton was found some years ago in digging a well in the Kimeridge clay at Swindon; this specimen being now preserved in the British Natural History Museum at South Kensington. The back of this creature was protected by a number of large spines, but the skull (as is shown by nearly entire skeletons obtained from the Jurassic rocks of the United States) was devoid of horns, and distantly resembled that of the Iguanodon, although more depressed. The teeth of these reptiles resembled the specimen shown in Fig. 8, and were simpler and relatively smaller than those of the Iguanodon, although constructed on the same fundamental plan. This diminution in the size of the teeth, we may observe in passing, appears to be an instance of that tendency to a reduction or disappearance of the teeth in the specialised forms of many groups of animals to which we have alluded in an earlier article.

Fig. 8.—Side View of the Tooth of an Armed Dinosaur. Enlarged. (After Marsh.)

The Armoured Dinosaurs were also well represented in the Wealden (where they were first discovered by Dr. Mantell), although we have at present no evidence as to the nature of their skulls. One of these Wealden reptiles, which has been named the Hylæosaur (from the Greek *hulé*, "wood," in allusion to the Wealden, or wooded country), carried a formidable row of large flattened spines forming a crest down the back. The other, termed *Polyacanthus* (many-spined), is remarkable for having had the whole region of the loins and haunches protected by a continuous sheet of bony plate-armour, rising into knobs and spines, after the fashion of the carapace of those extinct armadillos known as Glyptodonts.*

The earliest evidence of the existence of the Horned Dinosaurs occurs in the greensand of Austria, but the specimens hitherto obtained from these deposits are too imperfect to give us any definite insight into the organisation of these reptiles. We accordingly turn to the upmost cretaceous rocks of the United States, where the remains which have been unearthed must excite the envy of all European palæontologists.

As their name implies, one of the most striking features in the organisation of these uncouth monsters is the presence of large horn-cores on the skull, as shown in Fig. 9. The skull of which we give a figure is remarkable not only for its gigantic size—the length of the figured specimen, which is said to indicate an immature individual, being about six feet—but also for its peculiar armature and structure. An imperfect skull of another species exceeds these dimensions, huge as they are, and is estimated when entire to have had a length of over eight feet. No other known animals, except whales, have a skull making any approach to these dimensions; that of the huge Atlantosaur being very small in comparison with the bulk of its owner. The skull before us is likewise remarkable for its wedge-like form when viewed from above, and carries a pair of large horn-cores immediately over the eyes, and a short and single core above the nose. During life it may be inferred with a high degree of probability that these bony cores were sheathed with horn,

* See the article on Mail-Clad Animals in Knowledge for November 1889.

like those of oxen, and that they proved equally effective weapons of defence.

The structure of the teeth is somewhat similar to that obtaining in the Iguanodon, but each tooth has two distinct roots. As in the latter, the extremity of the lower jaw is devoid of teeth, and likewise has a separate terminal bone. The upper jaw is, however, quite peculiar in having a distinct toothless bone at the extremity of the muzzle; so that it would seem probable that the mouth of these reptiles formed a kind of beak sheathed in horn like that of a tortoise. In young individuals the front horn-core is a separate ossification, but in the adult it became firmly united to the underlying bones, so that in this respect we have a precise analogy with the horn-cores of the giraffe. The brain of the creature is very minute—relatively

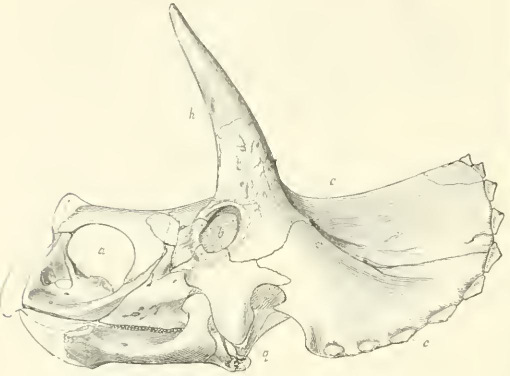


FIG. 9.—SIDE VIEW OF THE SKULL OF A HORNED DINOSAUR. $\frac{1}{20}$ nat. size. *a*, nostril; *b*, eye; *hh'*, horn-cores; *r*, upper part of beak; *p*, lower part of beak. (After Marsh.)

smaller, indeed, than in any known Vertebrate; this, however, might have been expected from the diminutive size of the brain in other Dinosaurs, since, in the same groups, large animals always have relatively smaller brains than their smaller allies.

The pelvis of the Horned Dinosaurs is quite unlike that of any members of the group; the pubis being constructed on the plan of that of the Iguanodon, but with the loss of the bar running backwards parallel with the ischium. It thus results that the pubis is represented only by an exaggeration of the process marked *p*. in the pelvis of the Kiwi; this process occupying the same portion as the pubis of the Megalosaur (Fig. 6), but not corresponding to it, since that pubis represents the backwardly-directed bar of the pubis of the Iguanodon. This assumption of the same function and position by a totally different bone is a very remarkable, although not an unique feature, and indicates the extreme specialisation of its owner.

With this brief reference to the Horned Dinosaurs, we close our survey of the Giant Land Reptiles. In a short sketch like the present it is, of course, quite impossible to do more than glance at a few of the more striking features of the organisation of these most extraordinary creatures. The reader who has followed us throughout will, however, have acquired some general idea of their chief peculiarities and affinities; and he may profitably endeavour to realise in his mind's eye the aspect of a world in which the land-surface was peopled by these uncouth reptiles, of all shapes and sizes, while the air was tenanted by the weird Flying Dragons, of which we have treated in a previous article.

THE BREATHING ORGANS OF PLANTS.

By J. PENTLAND SMITH, M.A., B.Sc.

VEGETABLE organisms are composed originally of one or more small spherical sacs called *cells*. Each sac consists of a living mass of protoplasm (πρωτος, first and πλασμα, form), or first formed material, which has surrounded itself with a wall of cellulose, a substance of like composition to starch, but which differs from starch in many important respects. The primordial cells of the higher plants undergo many modifications, which accord with the functions they have to perform; division of labour induces change of form. Not the least interesting of the modifications which they exhibit are those which culminate in the production of the breathing organs which form the subject of this paper.

Scattered over the surface of all land plants are numerous minute apertures, which, from the power they possess of opening and closing, are termed *stomata* (στομα, a mouth). Not only do they occur on the leaves, the chief assimilating organs of plants, but they appear in greater or less numbers on young stems and on the parts of the flower, and may even be developed on the young underground stem or tuber of the potato.* In fact, the only portion of the plant on which stomata are not found is the root; the reason of this will soon appear sufficiently obvious.

If the outer layer of skin, or *epidermis* (ἐπι, upon, and δερμα, the skin), be peeled from off the underside of a leaf, and placed in a drop of water on a glass slide, with a cover-slip laid over it, and then examined under a moderately high power with a microscope, it will be found to be pierced here and there with apertures large and small, the size of which is determined by the species of plant from which the epidermis has been derived. But a much simpler method of proving the existence of these openings in the skin-like structure is to place the cut end in water, and to blow into the blade which has been inserted in the mouth. Bubbles of gas will then appear at the cut end, and will rise to the surface of the water.

Illustrations of the lower epidermis of the leaves of five species of plants treated as described above are shown in Fig. 2, *a*, *b*, *c*, *d*, *e*; their names are as follows: *a*, Hoya; *b*, Scolopendrium vulgare, the hart's tongue fern; *c*, Lilium candidum, the white lily so much in request at the present time in floral decorations; *d*, the cabbage, Brassica oleracea, var.; *e*, Iris.

From calculations based on measurements made on 150 different plants, the German botanist, A. Weiss, found that the length of these stomata varied from ·016 to ·076 millimetres, the breadth from ·016 to ·079 millimetres, and the area from ·00011 to ·0049 millimetres. Substituting the British for the decimal system, we find that the so-called breathing organs of plants exhibit lengths varying approximately from $\frac{1}{1562}$ to $\frac{1}{313}$ inches, lengths of from $\frac{1}{1562}$ to $\frac{1}{312}$ inches, and superficial areas from $\frac{1}{6250000}$ to $\frac{1}{125000}$ inches. They are found in millions on the surface of plants; as many as one hundred to two hundred are common numbers to find on one square millimetre of

* The potato, a staple article of diet, is a fleshily thickened underground *stem*, whose cells are packed full of starch, and whose *eyes* are dormant buds. It is these buds which develop later on into the potato stem which appears above ground

the under surface of leaves. By a comparison of the diagrams of Fig. 1 with those of Figs. 2 and 3 a tolerably correct idea of the structure of the ordinary stoma may be obtained. In each case *two cells*, termed the *guard-cells*, surround the stoma; and these are contiguous at each end of the slit. The whole apparatus is elliptical in outline, and the longer axis of the ellipse generally assumes the same direction as that of the structure on which the stoma arises. Each of the stomata depicted in the figures has arisen by a splitting of a cell of the epidermis; but nevertheless they differ in many important respects from the cells which surround them, and also exhibit differences among themselves chiefly as regards their relative positions. In the first place it is plainly evident that, with the exception of the Fern (Scolopendrium vulgare), chlorophyll or green-colouring matter is absent from all the epidermal cells except the guard-cells, which are densely packed with chlorophyll granules. In the second place, the walls of the guard-cells exhibit a difference in thickness, those portions next the apertures, and those contiguous to the

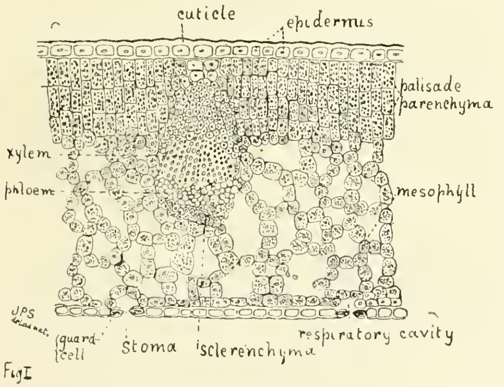


Fig. 1.—Transverse Section of the Leaf of *Osmanthus*. The cuticle is the continuous outer coat of the epidermal cells. The *xylem* (ξυλον, wood) is the technical name applied to the wood, the tissue which is the chief conductor of the sap up the stem. *Phloem* (φλέω, to overflow) is the tissue which carries down the elaborated sap. *Sclerenchyma* (σκληρος, hard) is thick-walled supporting tissue. The *mesophyll* (μεσος, middle; and φυλλον, a leaf) is the tissue which occupies the middle of the leaf: it consists of a loosely arranged tissue with many air-spaces amongst the cells.

epidermal cells which may be termed the lateral walls, are very thin; while, on the other hand, the walls facing the outside of the leaf, and in part lining the respiratory cavity, have become much thickened. Furthermore, the position of the whole stomatal apparatus is subject to variation. In the Crassula and White Lily (Fig. 3, *a*, *c*) the guard-cells are almost on a level with the other epidermal cells, whereas in the Iris and Horse-tail (Fig. 3, *b*, *d*) they are in the one case half, and in the other wholly, surmounted by these cells. The two lateral adjacent cells of the epidermis in the case of the Sedum form part of the stomatal apparatus; they are termed the *subsidiary cells of the stoma*. The stomata of Nerium, the Oleander, and a climbing plant common in our greenhouses, occupy a peculiar position. On the surface of the leaves are numerous pits; each of these is half filled with hair-like appendages, projections of the cells lining the pit, and at the base are situated the stomata, two, three, or more in number. In all cases the stomata open into an intercellular space, the so-called "respiratory cavity," which is enclosed by thin-walled cells containing chlorophyll. Figure 2 and its description give fuller information on the stomatal surroundings. There are many anomalous forms of stomata, which the reader can easily find out for himself by adopting the simple methods described in the footnote.*

With these we will not at present deal, but will proceed to discuss the mechanism of the stomata and the use of the stomata to the plant.

The mechanism of the stomata is a subject which has received the attention of many botanists, but no satisfactory solution of the problem has yet come to hand. The following may be taken as a general statement of the present views on the case. In the guard-cells are many granules of the green colouring matter, chlorophyll. The presence of these induces during daylight carbon assimilation. In other words, in these, as well as in the other chlorophyll-bearing cells, the carbon dioxide of the air, commonly but wrongly spoken of as carbonic acid gas, is decomposed into its constituent elements—carbon and oxygen. The carbon and part of the oxygen are retained by the cells, and the rest of the oxygen is given out again to the atmosphere. The carbon and oxygen then unite with water which is present in the cells. The using up of this water causes a fresh supply to be drawn in from the surrounding cells. This supply probably comes, in the case of the guard-cells, from the surrounding epidermal cells, and the process goes on continuously during sunlight, so that the guard-cells are during that period always kept filled with a watery fluid, and thus rendered turgid. Turgidity causes a straightening of the thin lateral walls of the guard-cells, and a simultaneous curving of each of these cells in such a manner as to open the orifice. On the other hand, when the guard-cells become flaccid, as they do at night, the orifice is closed.

A few general remarks on vegetable physiology form a necessary introduction to a discussion on the function of the stomata. As we stated above, protoplasm is the essential portion of the plant; it is the vital substance by whose activity all the other portions of the organism are built up. Its composition is extremely complex; no chemical formula can be assigned to it, but it is known that the elements carbon, hydrogen, oxygen, nitrogen,

* As many of our readers are doubtless the possessors of a microscope, perhaps the following hints on the preparation of slides for microscopic use will be appreciated. If it be wished to make an examination of the epidermis of the leaf, the leaf should be steeped for some time in water and then folded round the fore finger of the left-hand. The operator can then peel off a portion of the epidermis by inserting a needle mounted in a handle into the leaf near the thickest vein or midrib, and then working gently under the epidermis in a direction away from the midrib. To obtain a cross or transverse section, that is one at right angles to the blade of the leaf, requires more skill and practice. A part of the leaf should be placed in a slit made in a piece of carrot or pith, and then with a very *sharp* hollow ground razor, thin sections of both carrot and leaf should be cut off. The razor should not be forced right across the object, but should be worked with a sliding motion from heel to tip. Both the object and the razor must be kept wet with dilute methylated spirit. The sections obtained should be transferred to a watch-glass containing water and methylated spirit, and then the thinnest of these having been selected, they can be permanently mounted by placing them, one in each case, by means of a camel-hair brush, on a glass slide measuring 3 inches by 1 inch. The superfluous water must now be drained off with a piece of blotting-paper; then some glycerine jelly must be gently lowered on the section with a glass rod. The whole must then be covered with a thin glass cover-slip of $\frac{3}{4}$-inch diameter. The epidermis may be mounted in the same manner.

N.B.—The needles in handles, glycerine jelly, slides, and cover-glasses, can all be obtained from any dealer in microscopical appliances. They are quite inexpensive. The glycerine jelly requires to be heated before use.

sulphur, and probably phosphorus, enter into its constitution. That a plant may be able to elaborate its protoplasmic material, it must be supplied with those elements. They have for this reason been termed the *essential elements* of plant food. But in addition to these the presence of potassium, magnesium, and iron has been found necessary for the healthy and vigorous development of the plant. The question now arises, From what sources does the plant obtain these elements? The answer is, From

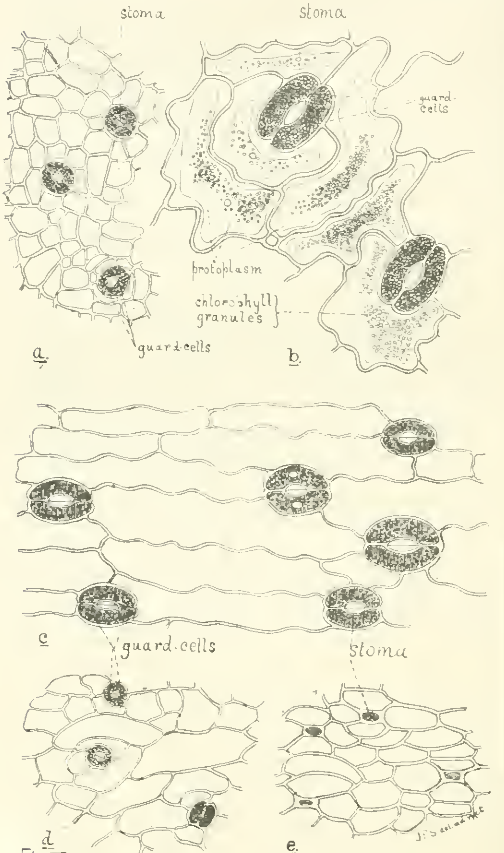


FIG. 2.—EPIDERMIS of—*a*, Hoya; *b*, Scolopendrium vulgare: *c*, Lilium candidum; *d*, Brassica oleracea, Cabbage; *e*, Iris.

the soil and from the air. The air furnishes it with carbon and oxygen; the other elements are derived from the soil. The mode of obtaining carbon and oxygen we have just described: but, besides, in the air there is a great quantity—$\frac{1}{5}$th part by volume—of free oxygen, so that for the purpose of respiration the plant can obtain it, so to speak, ready-made. It seems very strange, but still the statement is supported by numerous experiments, that although there is as much as 80 per cent. of free nitrogen in the atmosphere, plants do not make use of it, in preference taking it in the combined forms from the soil. The organs which are the absorbents of carbon and oxygen are the leaves, and also the stem when it contains green colouring matter; while by means of numerous hairs, which are developed at a little distance behind their growing point, the young roots absorb the nutrient material from the soil. Before a substance can pass into a plant it must be in solution in water; this applies to gases as well as to solids. The soluble salts of the soil are present there in very dilute solutions, and it is only as such that the plant is capable of receiving them. Taking into consideration the exceedingly dilute state in which the salts are absorbed, and the large quantity of the elements which compose them required by the plant to enable it not only to increase in size, but even to live, it will be seen

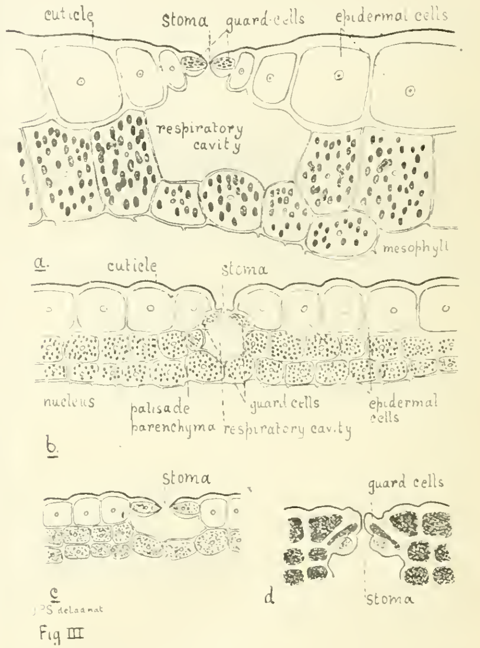


FIG. 3.—*a*, Transverse section of stomatal apparatus of Crassula napus; *b*, Iris; *c*, Lilium candidum, White Lily; *d*, Equisetum arvense, Horse-tail.

that a great volume of liquid must be taken in by the roots of plants. The absorbed liquid forms what is generally termed the *sap*. It travels up the stem chiefly by way of the wood to the chlorophyll-bearing cells, where it unites with the carbon and oxygen obtained by these cells from the air. Only a very small quantity, however, of the absorbed water is required by the plant. The superfluous water must be given off to promote fresh absorption by the roots. This giving off of water is termed *transpiration*, and it is the function of the stomata to regulate this process. The most active transpiration takes place when the stomata are open, and it is also at this period that carbon assimilation is proceeding with the greatest vigour. The two processes are thus closely connected the one with the other, and the mechanism of the stomata is wonderfully

adapted to subserve the requirements of both. The stomata are then, properly speaking, the *transpiring organs* of plants. How is it they have acquired that name which has furnished the heading to this article? Although all plants which contain chlorophyll inhale during sunlight carbon dioxide and exhale oxygen, they nevertheless exhibit a phenomenon the antithesis of this, namely, that of respiration, the inhalation of oxygen and exhalation of carbon dioxide, processes identical with those which take place when an animal breathes. And just as in an animal breathing must go on continuously during its life, so the phenomenon of respiration is a continuous one in plants, differing in this respect from the intermittent process of carbon assimilation. The latter is so much in excess of the former, however, during bright sunlight as almost to completely obscure it. It is doubtless the case that the carbon dioxide and oxygen which are absorbed by a plant go in chiefly by way of the leaves, but that the stomata are of especial importance in this connection is open to doubt; in fact, Boussingault has proved that the leaves of the Poplar, Chestnut, Peach, &c., absorb carbon dioxide more readily by their upper than by their under surfaces, although stomata are more numerous on the latter than on the former. Unquestionably they afford means of exit to carbon dioxide during respiration, and to oxygen during carbon assimilation; but the regulation of transpiration, or exhalation of watery vapour, is the true function of those organs which were held by the old botanists to be all important in respiration, and hence named by them the breathing organs of plants.

COLOURED STARS.

By J. E. Gore, F.R.A.S.

On a clear night a careful observer will notice a marked difference in the colours of the brighter stars. The brilliant white or bluish white light of Sirius, Rigel, and Vega contrasts strongly with the yellowish colour of Capella, the deeper yellow or orange of Arcturus, and the ruddy light of Aldebaran and Betelgeuse. These colours are, however, limited to various shades of yellow and red. No star of a *decided* blue or green colour is known, at least among those visible to the naked eye in the Northern Hemisphere. The third magnitude star Beta Libræ is described by Webb as of a "beautiful pale green hue"; but probably such a tint in the light of this star will to most people prove quite imperceptible. Dr. Gould, observing it in the Southern Hemisphere, says: "There is a decidedly greenish tinge to the light of β Libræ, although its colour cannot properly be called conspicuous."

Among the ruddy stars visible to the naked eye, Herschel's "garnet star" Mu Cephei is generally admitted to be the reddest, but it is not sufficiently bright to enable its colour to be well distinguished without the aid of an opera-glass. With such an instrument, however, its reddish hue is striking and beautiful, and very remarkable when compared with other stars in its vicinity. Like so many of the red stars, Mu Cephei is variable in its light; but it seems to have no regular period, and often remains for many weeks without perceptible change. It may be seen near the zenith in the early evening hours, towards the end of October, and in this position its curious colour is very conspicuous. Among the brightest stars Betelgeuse is perhaps the reddest; and the contrast between its ruddy tint and the white colour of Rigel, in the same constellation, is very noticeable. Like Mu Cephei, Betelgeuse is irregularly variable in its light, but not to such an extent, and, like the "garnet star," it frequently remains for lengthened periods nearly constant in brightness. There are other cases of reddish colour among the naked-eye stars. Among these may be noted Antares, Alphard (Alpha Hydræ), noted as red by the Persian astronomer Al-Sufi, in the 10th century, and called by the Chinese "The Red Bird"; Eta and Mu Geminorum, Mu and Nu Ursæ Majoris, Delta and Lambda Draconis, Beta Ophiuchi, Gamma Aquilæ, &c., and others in the Southern Hemisphere.

But it is among the stars below the limit of naked-eye vision that we meet with the finest examples of the red stars. Some of these are truly wonderful objects. The small star No. 592 of Birmingham's Catalogue of Red Stars (No. 713 of Espin's edition), which lies a little south of the $5\frac{1}{2}$ magnitude star 79 Cygni, was described as "splendid red" by Birmingham; "very deep red" by Copeland and Dryer; and "orange vermilion" by Franks. The star Birmingham 248, which lies about 5 degrees south of Nu Hydræ, is another fine specimen. Birmingham described it as "fine red" and "ruby"; Copeland as "brown-red"; Dreyer as "copper-red"; and Espin as "magnificent blood-red."* This star is variable in light, as the estimates of magnitude range from 6·7 to below 9. About 3 degrees to the north-east of this remarkable object is another highly-coloured star, known as R. Crateris. It is readily found, as it lies in the same telescopic field of view with Alpha Crateris, a $4\frac{1}{2}$ magnitude star. Sir John Herschel described it as "scarlet, almost blood-colour; a most intense and curious colour." Birmingham called it "crimson," and Webb "very intense ruby." Observing it with a 3-inch refractor in the Punjab in 1875, I noted it as "full scarlet." It varies in light from above 8th to below 9th magnitude, and has near it a star of the 9th magnitude of a pale blue tint.

Another very red star is No. 4 of Birmingham's Catalogue, which will be found about 5 degrees north preceding the great nebula in Andromeda. It is of about the 8th magnitude, and may be well seen with a 3-inch telescope. Krüger describes it as "intensiv roth," Birmingham as "fine red" and "crimson," Franks as "fine colour, almost vermilion," and Espin as "intense red colour, most wonderful."

Another fine object is R. Leporis, which forms roughly an equilateral triangle with Kappa and Mu Leporis. This also is variable from $6\frac{1}{2}$ to $8\frac{1}{2}$ magnitude. It was discovered by Mr. Hind in 1845, and described by him as "of the most intense crimson, resembling a blood-drop on the background of the sky; as regards depth of colour, no other star visible in these latitudes could be compared with it." Schönfeld calls it "intensiv blutroth"; but Dunér, observing its spectrum in 1880, gives its colour as a less intense red than that of other stars. Possibly it may vary in colour as well as in light.

The variable star U. Cygni, which lies between Omicron and Omega Cygni, is also very red. Webb described it as showing "one of the loveliest hues in the sky." It varies from about 7 to $11\frac{1}{2}$ magnitude with a period of about 461 days.

Another deeply-coloured star is the well-known variable

* The colour sensations produced by the light of the same star in the eyes of different observers probably differ and the words they select to describe and compare such colours differ more widely still. To my eye no star in the heavens appears nearly as red as the light from a railway-signal or the port-light of a ship. The light of such stars appears to my eyes as decidedly reddish, but not so red as the sparks from a locomotive as they die out, while the light from Vega appears to me decidedly bluish. Prof. Pickering's spectroscopic survey of the heavens will afford us a much more definite and satisfactory means of judging as to changes in the quality of the light of stars than we have hitherto possessed.—A. C. R.

R. Leonis. Hind says:—"It is one of the most fiery-looking variables on our list—fiery in every stage from maximum to minimum, and is really a fine telescopic object in a dark sky about the time of greatest brilliancy, when its colour forms a striking contrast with the steady white light of the 6 mag. a little to the north." This latter star is 19 Leonis.

In the Southern Hemisphere there are some fine examples of red stars. Epsilon Crucis, one of the stars of the Southern Cross, is very red. Mu Muscæ is described by Dr. Gould as of "an intense orange-red." Delta[2] Gruis is a very reddish star of about the 4th magnitude. Pi[1] Gruis was observed by Gould as "deep crimson," and forming a striking contrast with its neighbour, Pi[2] Gruis, which he notes as "conspicuously white." The variable L_2 Puppis is described as "red in all its stages, and remarkably so when faint." Miss Clarke observing (at the Cape of Good Hope) R. Doradûs, another southern variable, says:—"This extraordinary object strikes the eye with the glare of a stormy sunset,"* and with reference to the variable R Sculptoris, described by Gould as "an intense scarlet," she says:—"The star glows like a live coal in the field," a description I have found very applicable to other small red stars.

An 8th magnitude star about 5 degrees north of Beta Pictoris is noted by Sir John Herschel in his "Cape Observations" as "vivid sanguine red, like a blood drop. A superb specimen of its class." With reference to a star about 8½ magnitude in the field with Beta Crucis, Herschel says:—"The fullest and deepest maroon red; the most intense blood red of any star I have seen. It is like a drop of blood when contrasted with the whiteness of Beta Crucis."

Of stars of other colours the asserted green tint of Beta Libræ has already been referred to. Among the brighter stars of the Southern hemisphere Theta Eridani, Epsilon Pavonis, Nu Puppis, and Gamma Tucanæ are said to be decidedly blue. The wonderful cluster surrounding the star Kappa Crucis contains several bluish, greenish, and red stars, and is described by Sir John Herschel as resembling "a superb piece of fancy jewellery."

Among the double stars we find many examples of coloured suns. Of these may be mentioned Epsilon Boötis, of which the colours are "most beautiful yellow, superb blue," according to Secchi; Beta Cephei, "yellow and violet"; Beta Cygni, "golden yellow and smalt blue"; Gamma Delphini, of which I noted the colours in 1874 as "reddish yellow and greyish lilac"; Alpha Herculis, "orange and emerald or bluish green," and described by Admiral Smyth as a "lovely object, one of the finest in the heavens"; Zeta Lyræ, "pale yellow and lilac" (Franks), and Beta Piscis Australis, of which I observed the colours in India as white and reddish lilac.

Some distant telescopic companions to red stars have been described as blue. This may in some cases be due, partly at least, to the effect of contrast. In others, the blue colour seems to be real. This has been shown spectroscopically to be the case with the bluish companion of Beta Cygni.

The physical cause of the difference in the colour of stars is still more or less a matter of mystery. Although we cannot consider it proved that the red stars are cooling and "dying out" suns, as has been suggested, we may, I think, conclude that their temperature, although doubtless very high, must be lower than that of the white stars. We know that a bar of iron when heated to redness is not so hot as when raised to a "white" heat; and although the analogy between hot iron and stellar photospheres may not be a perfect one, it seems probable that the higher the temperature of a star the whiter will be its colour. Most of the white stars, as Sirius, Vega, and those only yellow or slightly coloured, show spectra of Secchi's first and second type, while the great majority of the red stars exhibit banded spectra of the 3rd and 4th types.

To this rule there are, however, like other rules, some notable exceptions. For instance, Aldebaran, Alpha Hydræ, Xi Cygni, and 31 Orionis, although distinctly reddish stars, show well-marked spectra of the 2nd or solar type. On the other hand, Rho Ursæ Majoris and Omega Virginis, which, according to Dunér, are only slightly yellow, have well-marked spectra of the 3rd type.

An apparent change of colour seems in some cases to be well established. The supposed red colour of Sirius in ancient times is well known, but that such a remarkable change of colour has really taken place in this now brilliantly white star is very far from being established. It seems more probable that the idea of change is due to the mistranslation of a word applied to the star by some of the ancient writers, a word which probably referred to its brightness, not to its colour. A certainly established change is, however, found in the case of the famous variable star Algol, which is distinctly described as red by Al-Sufi in the tenth century. It is now pure white, and this is probably the best attested instance on record of change of colour in a bright star.

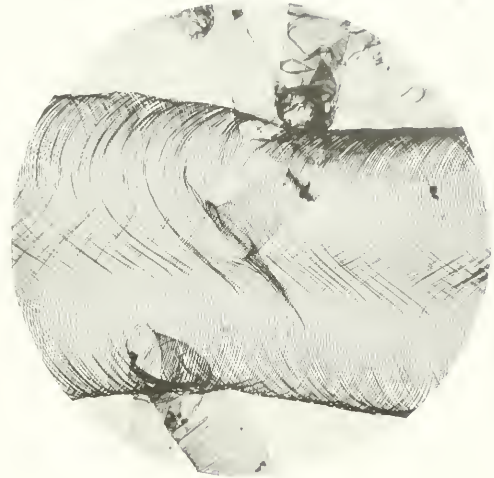
Schmidt's Nova Cygni of 1876 was noted as "golden yellow" on the night of its discovery. When it had faded to about the 8th magnitude, Dr. Copeland called it "decided red"; but when examined at Lord Crawford's Observatory in September 1877, its colour was recorded as "faint blue"! The new star in the Andromeda nebula was considered to be yellowish or reddish by most observers when near its maximum; but about a month later its colour was noted as "bluish." Possibly, however, these *Novæ* may be really nebulæ and not stars at all.

Among the red and variable stars there are many suspected cases of colour variation. Espin and other observers have noted that the wonderful variable Mira Ceti is much less red at maximum than at minimum. My own observations confirm this. When at its maximum brightness Mira does not seem to me a very highly-coloured star, while at one of the minima I noted it as "fiery red." Possibly, however, the great difference between its maximum and minimum brilliancy may have an influence on estimations of its colour. The remarkable variable Chi Cygni is said to be "strikingly variable in colour." Espin's observations in different years show it "sometimes quite red, at others only pale orange red." The star Birmingham 118 was described by Schjellerup in 1863 as "decided red," but was found yellow by Secchi in 1868, "bluish" by Birmingham, 1873–1876, "no longer red" by Schjellerup in March 1876, and "white" by Franks in 1885. Birmingham 169 was found red by Struve, blue or bluish white by Birmingham in 1874, and white at Greenwich in the same year. Espin also saw it white in March 1888. The star Birmingham 30, which lies close to Phi Persii (54 Andromedæ), was described by Schweizer as "etoile rouge presentant un petit disque" in Jan. 1843; Birmingham noted it "light red" in December 1875; Copeland "deep red" in Jan. 1876, and Dreyer "reddish" in September 1878; but Espin, in November and December 1887, found it "certainly not red, and nothing peculiar in the star's appearance." It might be expected that these curious changes of colour, if real, would be

* *Observatory*, Dec. 1885.

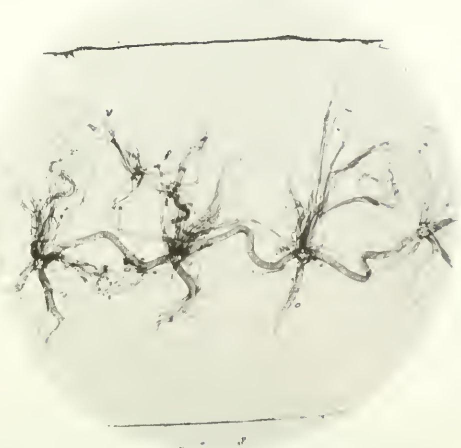
2. **WATER-BUG (Corixa)** viewed from beneath, magnified about 8 diameters. This insect lives in ponds, swimming chiefly by aid of its flattened and deeply fringed hind-legs. Owing to distortion caused by flattening the specimen for mounting, the front pair of legs, with their curious blade-like terminal joints, appear to proceed from the head; they may, however, be traced back to their origin in the prosternum. The extraordinary length of the tarsal claws in the intermediate legs will be noticed. The antennæ are, in these water-bugs, very short and concealed in depressions on the head; hence they do not appear in this specimen. The fore-wings are semi-transparent and prettily mottled with black and yellow; the division between clavus and corium is distinctly marked as a black line crossing the wing diagonally; the corium appears to shade off almost imperceptibly into the membrane at the tip of the wing. The hind-wings are extremely delicate in this genus, and it is difficult to preserve them intact in specimens mounted in balsam; in the present instance they were irretrievably damaged, and, being extremely transparent, scarcely any trace of them appears. The broad border to the abdomen is the connexivum.

1. **BED-BUG, FEMALE (Acanthia lectularia),** viewed from above, magnified about 9 diameters. In consequence of the flattening necessary for mounting as a transparent object, the abdomen is unduly elongated. The clear spaces between the segments are the parts in which the skin is not hardened by the accumulation of chitin, and these should not be visible, but the segments should appear closed up so as to make the dark parts continuous. For the same reason the head is thrust rather too far forward, and reveals the flexible skin by which it is attached to the thorax. Between the antennæ is seen the base of the rostrum or beak, the remainder of the organ being bent back underneath the head; the corneal surfaces of the eyes form two prominent swellings at the sides of the head. Immediately behind the head is the pronotum or upper surface of the prothorax, with projecting sides, and behind this are the two scale-like elytra or fore-wings, a litte more prominent at the sides than is natural, in consequence of the flattening. Between them lies the triangular scutellum. Inside the abdomen, a little below the middle, may be seen an egg, lying in a sloping position. The hairs which cover the body are most easily traced at the hind margins of the segments, where they show plainly against the clear background of flexible skin, which is not furnished with them.



4. **PORTION OF TRACHEA OF A LARGE WATER-BEETLE.** This specimen is more highly magnified than the preceding, and shows the internal structure of the tube. The cross lines are the coiled thread, which, as the specimen is very transparent, is seen in its whole course, and its apparent crossings are due to the difference of direction it takes on the upper and under surfaces, which difference, again, is largely due to flattening. In some parts smaller tubes are seen issuing from the main trunk, and the course taken by the thread under these circumstances may to some extent be made out.

3. **TRACHEÆ (Breathing-tubes) OF SILKWORM.** A main trunk is shown connecting four stigmata (orifices by which communication is maintained with the outer air). Round each orifice many tracheæ branch in various directions, subdividing and becoming smaller as they recede. The four stigmata would appear as oval marks down the side of the silkworm. The coiled thread inside the tracheæ, which prevents their collapse, can with difficulty be traced in this specimen, on account of the closeness of its coils.



accompanied by corresponding changes in the star's spectrum. Such may be the case, and observations in this direction would probably lead to some interesting results.

There seems to be some law governing the distribution of the coloured stars. The white stars appear to be most numerous, as a rule, in those constellations where bright stars are most abundant, for instance, in Orion, Cassiopeia, and Lyra; yellow and orange stars in large and ill-defined constellations such as Cetus, Pisces, Hydra, Virgo, &c. The very reddish stars are most numerous in or near the Milky Way, and one portion of the Galaxy—between Aquila Lyra and Cygnus—was termed by the late Mr. Birmingham "the red region in Cygnus."

THE BED-BUG.—III.

By E. A. Butler.

The eggs of the bed-bug are small, white, oval objects (Fig. 11); they are laid in cracks and crevices, and are caused to adhere to the surface on which they are deposited by a kind of varnish with which they are wet when laid. According to Southall, about fifty eggs are laid in each batch. The young bugs make their entry into the world by pushing off a kind of lid at the end of the egg, and the empty egg-shell then looks like a little round-bottomed china jar with a neat rim round the opening. The newly-hatched bug is a very minute, transparent, six-legged creature, showing no trace of the brown colour which characterizes it in adult life. It is sufficiently transparent to reveal something of its internal economy through the skin; and after it has had a meal of blood, a dark red spot appears in the region of its digestive apparatus. It has a broad, triangular head, and the antennæ are short, and proportionately much thicker than when full-grown. Of course, no signs of wings are apparent while the insect is in this immature condition (Fig. 12).

Fig. 11.—Egg of Bed-Bug.

Fig. 12. Newly-hatched Bug.

During the course of the larval life the skin is shed several times, each moult being accompanied by a closer approach to the form of the adult. The operation is effected in the same way as in the cockroach, viz. by the splitting of the skin along a straight line down the middle of the back in the region of the thorax, and the whole animal gradually extricates itself at this aperture, carefully removing not merely the more robust parts of the body from their covering, but neatly withdrawing also the more slender parts, such as the legs and antennæ, each separately from its own sheath. During the moult, the claws at the tips of the tarsi are useful in obtaining a foothold on the irregularities of the wood, paper, &c., on which the change takes place; by this means the shells of the limbs are prevented from becoming crushed and collapsed, and are enabled to retain their proper forms; hence, but for the distortion caused by the fracture along the back, and the paler tint, the cast skin (Fig. 13) might easily be mistaken for the insect itself.

The last moult but one introduces the form usually called the nymph (Fig. 14), which corresponds to the chrysalis of those insects whose metamorphosis is complete. As the bug grows with each moult its colour deepens, and its skin becomes harder and less flexible, so that when it has reached the nymph stage it closely resembles the adult, though still rather smaller. The chief differences perceptible are in the region of the hinder part of the thorax and the fore part of the abdomen. The prothorax is very similar to that of the adult, the leaf-like margins projecting by the sides of the head; the next two segments, however, have not become so specialised as will ultimately be their fate, and they appear as distinct bands right across the body. The first of them, which is the mesothorax, already shows, however, a slight indication, at the sides, of the outline of the fore wings. The next three segments are very similar to one another, and no distinct line of division shows where the thorax ends and the abdomen commences. But if we remember that the thorax consists in all of only three segments, and that the first of these is the very distinctly marked prothorax, the determination of the line of junction of the chief regions of the body becomes easy.

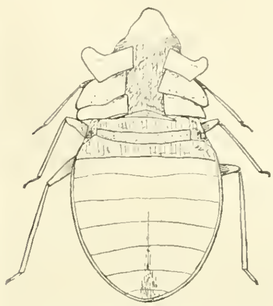


Fig. 13.—The Cast Skin of an Adult Bug, seen from above.

While in the nymph condition the bug is still just as active as before, and continues to take food with equal readiness. At length the final moult occurs, and the insect is sexually mature, and acquires its rudimentary elytra, or upper wings. No further growth takes place, as, owing to the inflexibility of the skin, this can only be effected by moulting. The food now taken, therefore, serves not for increase of bulk, but to maintain the proper balance of the activities of the body and to supply materials for the perfecting and discharge of the reproductive

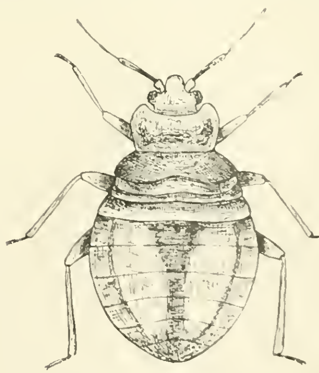


Fig. 14.—Bed-Bug at the Nymph Stage.

functions. The insect is said to require in all about eleven weeks to reach maturity, but the exact duration of its metamorphoses is no doubt greatly dependent upon the regularity and amount of the supply of food. In the adult condition it can certainly endure long fasts with impunity; De Geer kept several in a sealed bottle for more than a year without food. It is also a well-known fact that bugs sometimes absolutely swarm in houses that have for a long time been uninhabited. In such cases it is obvious that they have managed to exist without access to human blood; still it does not necessarily follow that they have been entirely without food of any kind, and when we remember that their human parasitism is probably an acquired habit, their appearance under such conditions will be less difficult to understand.

It has been supposed that they are able to abstract juices sufficient to support life from the wood-work of buildings, and if we take into consideration the absorptive properties of unpainted soft woods, such as deal, it seems far from incredible that such may be the case. That an insect which has been accustomed during the greater part of its individual life to subsist upon animal matter should suddenly change its diet and feed upon vegetable substances, or upon mere inorganic moisture, and the slight amount of organic matter that may contain in solution, would in most cases be an unprecedented proceeding, and there are hosts of insects which would rather starve than do it. But it is not at all an unusual circumstance in the order Hemiptera, and several of the wild bugs seem to be quite indifferent as to whether they are supplied with an animal or a vegetable diet. Another suggestion by which it has been proposed to account for their presence in uninhabited houses is that the colony having been established during the human occupation, they have, since the desertion of the premises by their hosts, preyed upon one another, and so sustained life. But an obvious objection to the theory is that by such a course their numbers would be speedily thinned, and the colony would probably soon become extinct, a result which by no means tallies with experience. If in such cases the bugs really found any difficulty as to the commissariat, of course migration would be open to them, and it is difficult to believe that, enterprising as they are, they would not avail themselves of such an expedient, if really hard pressed by famine.

While it may be admitted that the hard-skinned, ungrowing adults can subsist for long periods without food, it is probable that the younger and softer skinned forms, in whose bodies the vital processes are more rapid, require more frequent supplies. Such, at any rate, is the experience of those who have attempted to rear any of the wild species of Hemiptera with which our woods, fields, and hedges swarm. As the surest and safest way of avoiding bugs in the house is the cultivation of scrupulous cleanliness, it would seem probable that the miscellaneous material included under the name "dirt," which is, much of it, of organic origin, may contribute in some way to their support; but still it must be borne in mind that, owing to the peculiar structure of their mouth organs, whatever be the nature of the material from which they derive their food, only its liquid portions can be partaken of. Anyhow, there seems little doubt that human blood is not an absolute necessary of life to this disgusting parasite, and perhaps may be more correctly regarded as a luxury; and it is quite possible that before its association with mankind, *Acanthia lectularia* may have been a purely vegetable feeder, subsisting on the sap of trees. Southall declares that he fed the numerous families he kept on such food as this, using chiefly deal for the purpose. Hard woods, such as oak, walnut, and mahogany, or scented woods such as cedar, they failed to extract any nutriment from, and died if confined with these alone.

In our last paper a passing reference was made to the *Corixa*, as exhibiting some of the most beautiful developments of hind-wings to be met with in the whole order Hemiptera. The photographs accompanying the present article give the opportunity of contrasting the fore-wing of one of these insects with the rudimentary scale-like elytron of the bed-bug, as well as of comparing it with that of the field-bug figured last month. It will be observed that there is a similar composite structure of the wing—corium, clavus, and membrane being present, though no part of the first-mentioned is divided off from the main body to form a cuneus. It is perhaps difficult to realise at first sight that insects so widely different in appearance and habitat as the *Corixa* and the Bed-bug, nevertheless belong to the same order. Though so utterly dissimilar in shape, however, the two insects are constructed on what is essentially the same type or plan, their mouth organs being almost identical in form and arrangement, and the method of their growth and development, and the cycle of changes they pass through, entirely similar. Hence we see that an insect's systematic position is to be determined, not by its habits or method of life, nor by the actual form even of its body or of many of its organs, since similarities in these respects often co-exist with profound differences in other and more important particulars; and, on the other hand, the greatest divergence in habits, form of body, and nature of limbs and antennæ, may be observed in insects that are in other and more essential respects closely alike. Attention should therefore be paid specially to three points in determining the systematic position of any insect, viz. the nature of its mouth organs, the structure of its wings, and the kind of metamorphoses it passes through; insects which are alike in these respects may be regarded as intimately related to one another, and as referable to the same order, however they may differ in other ways.

Like all other insects, bugs, of course, breathe by inhaling air, not at the mouth, but at certain openings in other parts of the body, whence it is passed along delicate tubes (*tracheæ*) to all parts of the system. The stigmata, or openings to the tracheæ, are in the present instance extremely small, and therefore not easy to trace. They are situated on the under surface of the abdomen, not far from the edge of the body. Perhaps the best way to see them is to remove the chitinous band which forms the boundary of any of the central abdominal segments on the under side, and, after relieving it of any adhering viscera, to examine it with the compound microscope. A low power will be sufficient to show the stigmata, one on each side, as minute roundish openings surrounded by a rim-like lip. From these pass the main tracheal trunks, the branches of which, like tiny threads of silver, run hither and thither over the body. Their silvery appearance is due to the air they contain. The body of the living or freshly-killed bug is usually sufficiently transparent for some of the chief branches to be traced from the outside.

The accompanying photographs show the corresponding organs of a water-beetle and a silkworm, and will serve to indicate, more clearly than any verbal description can do, the sort of thing that is to be looked for in a dissection. The structural details cannot be properly made out till the tubes are removed from the surrounding organs and freed from the air they contain. The fine thread which projects round their inner walls prevents collapse; and so well does it perform its function that even in the dead and dried bodies of bugs, however ancient, such as

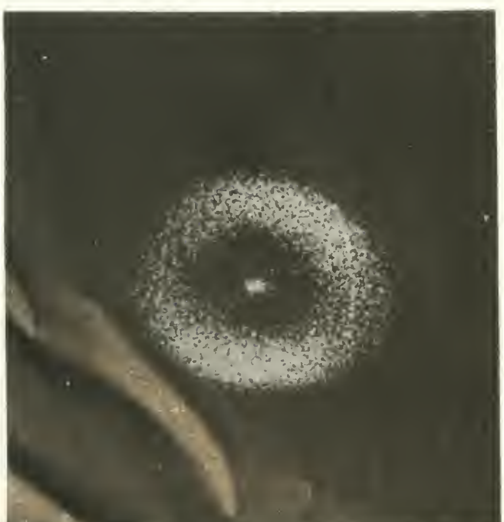
Photograph of the Planet Jupiter.

Taken by Prof. W. H. PICKERING, with an exposure of 87 seconds, and telescope of 13 inches aperture. 1889, July, 12d. 19h. 38m.

Photograph of the Planet Saturn.

Taken by Prof. W. H. PICKERING, with an exposure of 6m. 16s., and telescope of 13 inches aperture. 1889, February, 7d. 18h. 54m., G.M.T.

N.



Annular Nebula in Lyra R.A. 18h. 48m. N.P.D. 57 8.

From a photograph taken by M. TREPIED, at the Algiers Observatory, with six hours exposure.

N.

W.

Mr. Lassell's Drawing of the Annular Nebula in Lyra

Made in 1860 with his four-foot reflector.

may sometimes be found in swarms behind panels and wainscoting in badly infected houses, the tracheæ can still be recognised as perfect tubes after all the rest of the soft parts have dried up and disappeared. All that it is necessary to do with the dried carcase is to soak it in water till it becomes sufficiently flexible to be manipulated without breaking. On cutting through the skin, the tracheal tubes will be found spreading about in various directions, and may be examined where they lie, or removed and placed between glass, when a high power may be brought to bear upon them. There is no object in insect anatomy that is more easily identifiable than these breathing tubes, or more easily demonstrable, and hardly any that forms a more beautiful and attractive subject of study or exhibition.

(*To be continued.*)

Notices of Books.

Soils and their Properties. By Dr. W. Fream, B.Sc., LL.D. (George Bell and Sons, London.) This book will form a welcome addition to the library of the scientific farmer. It gives a brief account of the constitution of soils in different parts of the British Isles, tracing them back to their parent rocks, and describing, without too much technicality, their more important physical and chemical properties. A soil composed entirely of one constituent rock frequently lacks the essential elements of fertility. Thus a pure clay, a pure limestone, or a pure sand is incapable of growing crops, whereas a soil consisting of a suitable mixture of these ingredients is likely to be very fertile.

All gravel and sand is not the best land:
A rotteny mould is land worth gould.

The reason that alluvial soils are generally so fertile is the mixed character they possess, owing to their having been derived from the disintegration of various kinds of rocks. Not uncommonly the admixture of a rock that supplies the deficiencies of another takes place naturally along the line of outcrop of two geological formations of very different character. Dr. Fream's book is full of suggestions likely to stimulate the farmer to close observation of the processes of decay of rocks, of the action of water, drainage, frost, and wind, and of the work of the little micro-organisms which appear to act as the carriers of nitrogen between the enormous reservoir of the element contained in the atmosphere and the roots of plants.

Monograph of the British Cicadæ. (Parts 3 and 4.) By G. Bowdler Buckton, F.R.S. (Macmillan and Co.) In these two parts the genera and species from *Dicranotropis* to *Euacanthus* are described and illustrated, and most of the largest and best known of our species thus come under review. The dryness of descriptive details is relieved in Part 4 by some exceedingly interesting matter of a more general character, and questions such as those relating to the sound-producing apparatus of the chirping *Cicadæ*, and the condition of the organs of special sense in the froghoppers generally, are ably discussed. The attractive but little worked subject of life histories comes in for a brief notice, though very little light can be thrown upon it. There are great difficulties in the way of the artificial rearing of insects such as these, which subsist entirely on the juices of living plants; and even when the observer is successful in keeping the insects alive in confinement for any length of time, the secrecy of some of their operations, combined with the smallness of their size, renders the task of watching them doubly difficult. Mr. Buckton records some interesting observations made on the beautiful green *Tettigonia viridis*, Linn., one of the handsomest of our species, a colony of which he kept for some weeks under glass shades within which rushes were growing; but even under such favourable conditions, he failed to discover the mode of oviposition. A curious figure is given of a mass of "cuckoo spit," which had hardened into a reticulated ball containing the dead insect within it.

An Illustrated Handbook of British Dragonflies. By the Editor of the "Naturalist's Gazette." (Naturalists' Publishing Co., Birmingham.) There are scarcely any insects so misunderstood, popularly, as Dragonflies, and to all who would like to know the truth about them, we would recommend a perusal of this capital little manual, in which the author has put together all that a beginner needs as an introduction to the study of the group. There are descriptions of all the British species, forty-five in number, as well as an accurate account of their structure, habits, and life history, and instructions as to collecting, preserving and rearing them. A number of excellent illustrations, exhibiting most of our commonest species and their transformations, adorn the pages, and will be found a most useful aid to the student in his indentifications. We congratulate the author on having produced a thoroughly useful and reliable little handbook, which will, we trust, speedily find its way into the hands of many entomologists.

THE ANNULAR NEBULA IN LYRA.

By A. C. Ranyard.

We owe the photograph of the Ring Nebula in Lyra, shown in the plate, to the courtesy of M. Trépied, the Director of the Observatory at Algiers. It is an enlargement from a photograph taken by him with an exposure of six hours in the principal focus of one of the 13-inch achromatics which have been prepared by the Brothers Henry for the international work of the photographic survey of the heavens. It was taken in August last, and was one of the first-fruits of the instrument after it was mounted at the Algiers Observatory. The photograph was made with two exposures on successive nights, the sensitive plate having been covered up and removed in the meantime, and replaced when the instrument had been brought into position by means of the finder with which the driving is controlled. It has since been enlarged 64 diameters, and the granulation of the original plate shows very obviously; the minute specks composing the nebulous ring must not, therefore, be mistaken for stars.

To the right hand of M. Trépied's photograph is a photographic reproduction of Mr. Lassell's celebrated drawing of the Nebula, made with his four-foot equatorial in 1860. Mr. Lassell's drawing is turned with the North point uppermost on the page, and the west or following side towards the right hand, and the photograph is turned to correspond in orientation with Mr. Lassell's drawing. The scale of our reproduction of Mr. Lassell's drawing is $1'' = 0{\cdot}015$ of an inch. It will be noticed that M. Trépied's photograph shows the central star as nebulous, and the rest of the field inside the annular nebula comparatively dark and not filled up with nebulosity as in Mr. Lassell's drawing. The central star also appears nearly symmetrically situated with respect to the elliptic ring of nebulosity, whereas in Mr. Lassell's drawing it is decidedly to the north-east of the centre. In describing it, Mr. Lassell says: "The star a little below the centre of the dark space in the Nebula is faint, and from its faintness, in

conjunction with my impression that it does not always appear precisely in the same place, I think that there may possibly be two nearly equal stars there, too faint to produce distinct sensations on the retina. I see no other stars whatever in the Nebula, nor have I the impression that even the brightest parts would break up into stars, even with far more optical power."

As is well known, the Nebula has since been shown to be gaseous; but M. Trépied thinks that in the original negative he has evidence of at least three small stars in the brighter parts of the ring. It will be noticed that the outline of the ring in M. Trépied's photograph is more nearly circular than in Mr. Lassell's drawing. The decrease in brightness of the ring near to either end of the longer axis of the ellipse is a marked feature of the Nebula, as seen in the telescope, and is shown in the drawings of Trouvelot (*Annals of Harvard Observatory*, Vol. 8, Plate 34) and Holden (*Washington Observations*, 1874, Plate VI). The fainter light of the extremities of the ellipse is also mentioned by Padre Secchi in the *Descrizione del Nuovo Osservatorio del Collegio Romano*, Rome, 1856, page 86. The decrease of brightness at the ends of the ellipse is also very distinctly recognizable in M. Trépied's photograph, and the southern side of the ring appears distinctly brighter than the northern.

The Nebula has also been photographed by Mr. Isaac Roberts, 31st July 1887, with an exposure of 20 minutes, in the principal focus of his 20-inch reflector; still more of the Nebula is shown upon his photograph, and the exposure has gone so far that the density at the ends of the ellipse is barely distinguishable as less than that at the sides. There is also a small projection or irregularity of the ellipse at the south-west end, which is well shown in the drawings of Trouvelot and Holden; but, curiously, neither of these observers show the star or nebulous mass at the centre, which is so clearly shown in M. Trépied's photograph as well as in that of Mr. Roberts, and in a small photograph taken by Herr Von Gothard in 1886. A valuable account of the chief drawings of this Nebula made up to 1875, is given in a paper by Prof. E. S. Holden, published in the *Monthly Notices* for December 1875.

The following fuller list of drawings and descriptions of the Nebula I owe to Mr. Sadler:—

Herschel, Sir John, "Phil. Trans.," 1833, Plate X., Fig. 29. Very symmetrical ellipse.

Earl of Rosse, "Phil. Trans.,' 1844, Plate XIX., Fig. 29. A curious drawing, with parallel bands of nebulosity in the interior, and wisps of nebulosity from the outside of the ring.

Sadler, "Engl. Mech.," Oct. 13, 1882, Misprint No. 2 for No. 1. Symmetrical drawing, giving places of small stars.

Brashear, "Engl. Mech.," Nov. 14, 1884. Symmetrical ring, ellipse too narrow.

D'Arrest, "Instrumentum Magnum Equatoreum," Plate 11, Fig. 5.

D'Arrest, "Siderum Nebulosorum Obs. Havnienses." Symmetrical sketch; no central star.

Holden, "Washington Observations," about 1875 or 1876. One of the best drawings, but no central star.

Trouvelot, "Astron. Engravings from Harvard Obs.," Vol. 8, Plate 34. Very good drawing; several small stars are shown in the nebulous ring, but none at the centre.

Lamont, "Annall Munich Obs.," Vol. 17, Plate 11, Fig. 14. Small symmetrical drawing.

Lassell. Drawing privately published; copy in Astronomical Society's rooms.

O. M Mitchel, "Sidereal Messenger," July 1846. Description, but no drawing.

The photographs of Jupiter and Saturn given in the plate are remarkable as showing the very different actinic action of the light from different parts of the discs. The light from the Polar regions of both Jupiter and Saturn has hardly impressed itself on the plate. The light from the equatorial regions of Saturn also seems to be deficient in actinic power.

THE COAL-FIELDS OF CENTRAL FRANCE.

By G. W. Bulman, M.A., B.Sc.

The coal-fields of Central France present some interesting peculiarities. In the north of that country the coal-bearing strata are a continuation of the Belgian coal-field, and, as was suggested by Godwin-Austin in 1856, and practically proved by the recent discovery of coal in Kent, are connected with the South Wales and Somersetshire basins.

The isolated, basin-shaped areas in which our coal measures lie is attributed to folding, and subsequent denudation of the higher and more exposed parts; but the coal of Central France occupies areas which were depressions in the older rocks before the time of its formation.

The whole question of the origin of coal is a difficult one, and admittedly unsettled. It is true there is a generally received theory, which assumes that there was a gradual sinking of the surface, with pauses during which beds of vegetable matter were formed by terrestrial growths *in situ*, but it confessedly presents many difficulties.

One of the most important contributions to recent geological literature is a work by M. H. Fayol on the French coal-fields, in which the theory of growth *in situ* is entirely rejected. At the commencement of his practical work in the coal-mines of Commentry, this gentleman, fresh from l'Ecole des Mines, and imbued with the prevailing theory—*la théorie des tourbières*, he calls it—was brought face to face with phenomena which, to him, were inconsistent with it. Twenty-six years' experience, during which he has had exceptional opportunities for studying the question, has led him to discard the generally received idea, and bring forward the theory that the coal-measures of Commentry are old lacustrine deltas.

Specially conceived to explain the phenomena of this area, M. Fayol's theory has naturally been extended to the rest of Central France, and to coal-fields in general. "I propose to show," he says, "that coal-measures are deposits formed by water-courses at their entrance into lakes, or into the sea." And whatever may be thought of this extension of his views, it must be admitted that if any case can be proved by scientific reasoning, experiments, and observation, M. Fayol has proved his for the coal-field of Commentry.

Every phenomena exhibited by these coal-measures can, he claims, be satisfactorily explained on his theory, and imitated in an artificial delta. On the other hand, he points out many facts which the rival theory utterly fails to account for.

The first section of the second part of his book is the record of the examination of the rocks of the coal-measures. It is remarkable for its minuteness, and the amount of labour it implies. The description is illustrated by numerous and elaborate plans and sections, which serve admirably their purpose of elucidating the text.

The coal-basin of Commentry is one of those numerous isolated formations scattered over the granitic and gneissic plateau of Central France. It is some $5\frac{1}{2}$ miles by 2 in

extent, and 2,296 feet thick, and lies in a depression in the older rocks. One of its most notable characteristics is the large proportion of coarse materials—80 per cent. of the strata are conglomerates, and similar rocks; in our own coal-measures conglomerates are the exception. We have also to note the want of parallelism among the beds; the great variation in nature and thickness of individual strata; that beds and sets of beds frequently disappear; the frequent occurrence of false bedding; that fragments of granite, sandstone, and other rocks are found in the finer grained deposits; the black sandstones which contain coal in all dimensions, from microscopic particles to masses and beds several yards in thickness.

The chief coal seam is known as *la Grande Couche*, of which a detailed description is given. It is chiefly remarkable for the great changes in thickness and composition which it undergoes. When followed from point to point it is found to change from an ordinary bituminous coal to cannel, boghead, bituminous shale, and even to sandstone and conglomerate. In thickness it varies from 0 to upwards of 90 ft. Sometimes the seam is pure coal from the floor to the roof, with a thickness of from 32 to 75 ft.; sometimes there are intercalations of shale, and even sandstone and conglomerate, which may reach a thickness of 26 ft. No fire-damp is disengaged from this seam, in which it differs from some of the other seams of the basin, but carbonic acid gas occurs. Towards the west it splits up into six different seams.

In our own country the enormous 30-feet seam of the Dudley coal-field breaks up into ten or fourteen different seams, and in the coal-measures of Northumberland and Durham it has been noted that most of the seams, when followed far enough, coalesce with some other seam. The roof and floor of the seam are variable both as to nature and form. The former is often of shale, and sometimes contains blocks of granite and quartz: it is frequently irregular, and contains fragments of coal mingled with the shale.

Below, the line of junction is also irregular, the coal frequently denticulating and digitating with the bed below. In many places, also, the coal has been eroded. It was the constant presence below the coal of fire-clay full of stigmaria in the Welsh coal-fields which led Sir Wm. Logan to the conclusion that these clays were ancient soils, and to the general adoption of the theory of growth *in situ*.

But, says M. Fayol, in the whole coal-field of Commentry there is not a single bed which resembles an ancient soil. The *Grande Couche* rests sometimes upon carbonaceous shale, sometimes upon sandstone, sometimes on conglomerate: in no part of the floor are there to be found traces of atmospheric action. All these details of the seam are illustrated by plans and sections.

M. Fayol takes us to precarboniferous times, and restores, from geological evidence, the physical features of the district when the deposition of the coal-strata began. The coal-measures lie in a depression in the older rocks which consist of gneiss, granite, granulite, mica-schist, microgranulite, porphyries, &c. A careful study of the composition of these is a needful preliminary to the study of the lithology of the coal-measures.

The laborious method of percentages employed by M. Fayol in this part of his work is one which has yielded many valuable results in various branches of geological research. Here it leads to the division of the coal-field of Commentry into several distinct lithological zones, shows the origin of the sediments, and enables us to follow step by step the formation of the strata. The method is as follows:—

Every pebble in a portion of a given bed is taken, and its nature, form, and size are noted. Then the percentage of each kind of rock at many different points is calculated. From this work it soon appears that these pebbles are identical with the previously studied rocks of the older formations. Moreover, the percentage of a certain rock is found to increase in one direction and decrease in another. This indicates at once the direction of the source from which that particular rock was derived, and the previous study of the surrounding district points to the place of the parent rock.

"I have found in the neighbouring mountains," says M. Fayol, "the origin of the greater part of the elements which enter into the formation of the coal-measures." The old rivers which brought the pebbles must have flowed along the lines thus laid down. The form of the pebbles further indicates the nature of the stream, and so gradually the shadowy outlines of the past fix themselves: the physical geography and climate of the carboniferous period in Central France are restored. An Alpine district appears. High and steep mountains of granite, granulite, and mica-schist surround a number of deep, but not large, lakes, scattered over the central plateau. Rain and atmospheric influences are at work, and pebbles, sand, mud, and vegetable matter are carried down into the lakes. Gradually the valleys are deepened, and the lakes filled up by the torrential water-courses from the hills. That of Commentry is fed chiefly by a mountain stream from the north, which enters by the valley of Bourrus, and another from the west, which enters by that of Colombier: the water flows out to the south by a single outlet.

Each stream forms its own delta, and these gradually increasing join each other, and finally fill the lake. A series of illustrations show how the deltas of the different streams approached each other.

Vegetable *débris*, and the finer sediments, are deposited in the creek between the two chief deltas, and form the chief coal-seam of Commentry—*la Grande Couche*. Another creek, on the other side of the delta, receives the vegetable *débris* which goes to form the coal-seam of Ferrières. In his experiments on sedimentation M. Fayol has shown that pebbles, sand, mud, and vegetable remains, carried by the same stream, may thus be deposited in separate beds. While these beds were being laid down, a geological incident took place which has left its mark among the rocks of Commentry. A huge landslip occurs among the mountains: the stream is dammed back, accumulates behind the barrier, and then with a mighty rush breaks through, and carries with it enormous masses of rock. Large angular blocks of stone are deposited among the strata of the lake. It is to be noted that Mr. Godwin-Austin, writing of these coal-fields of Central France, attributes the large blocks to the action of ice. But, according to M. Fayol, no trace of glaciers has been met with.

The climate of the period, as indicated by the great variety of the plants and insects, was warm and moist, like certain regions situated near the tropics at the present day. Rains were abundant, but not diluvial or extraordinary. That the streams which carried the fragments of granite, gneiss, &c., from the mountains, brought also the vegetation of the period to be thus separately deposited to form coal is M. Fayol's most important result. The form of the basin, he points out, and the coarse nature and lie of the beds, indicate a deep lake surrounded by high mountains, and fed by mountain torrents: the relations of the coal-seams to the other beds precludes the idea of intervals during which the area formed swamps for the growth of coal *in situ*.

Some interesting calculations as to the time required for the formation of the coal-measures are given. On the hypothesis of *growth in situ*, and a gradual sinking of the surface, 800,000 years would be required; for the hypothesis of deltas, 16,000 years; *la Grande Couche*, on the former view, would require 318,500 years, and on the latter, 2,500.

On arriving at the question of the origin of coal, M. Fayol asserts that *all* the varieties in the coal-field are formed directly by vegetable *débris* similar to that usually carried by streams. Vegetable fragments found carbonized in shales and sandstones are usually ascribed to drift, and since there is a gradual passage from such beds to pure coal, there is no reason to doubt that these latter may be formed in the same way.

A bed of conglomerate 26 ft. thick, intercalated with the chief coal-seam, presents great difficulties on the theory of original horizontality and growth *in situ*, but is easily explained on the hypothesis of deltas. An unusually severe flood carries coarse particles beyond the ordinary resting-place of such, and deposits them on a bed of vegetable *débris*; things return to their usual course, and nothing but vegetation is laid down on the gravel. Floods and changes of watercourses cause the coarser sediments to invade the finer; the latter are then found intercalated with the former. The numerous local disturbances which occur are easily explained as the result of the pressing out of the soft incoherent beds of mud by the weight of the sediment above.

The pebbles of granite found in the coal itself are thought to have been carried by the trees which form it. When the rivers cut through some already bedded vegetable matter, this, being denser by reason of the change already undergone, is deposited *with* the sand, and "black sandstones" are the result.

The cleavage of the coal, M. Fayol explains as a phenomenon of contraction. Upright trees occurring in coal have usually been taken as indications of growth *in situ*; and since such occur in the coal-basin of Commentry, it becomes necessary to show that they do not necessarily imply this.

M. Fayol shows that *upright* trunks form only a small percentage of the large number occurring in his special area; as the beds become coarser and less carbonaceous, the proportion of upright trunks increases; the rocks which contain the fewest trees have the largest proportion upright. And some of these perpendicular trunks are upside down, with their roots in the air! Many are without roots, and others have their roots damaged and bruised. Moreover, the roots of these upright trees have often greatly affected the stratification of the beds in which they lie: roots growing in the soil would not do so.

To ascertain the effect of heat and pressure on sediments containing vegetation, some experiments have been tried. Various animal and vegetable remains have been placed with water in tubes, boilers, &c., for various periods of time, and sometimes enveloped in sand, mud, &c. The following results have been obtained: At 15° to 20° C., under a pressure of 65 yards of water, an inflammable gas has been produced. Organic matter protected from the air decomposed very slowly; the rate of decomposition grows slower as time passes. Woody fibres, fibrous bark, and the epidermis of leaves and grains resist best; cellular portions, young branches, interior of grains, &c., decompose first. Weight is lost, and the residue becomes more carbonaceous. The alteration is about the same, whether the vegetable matter is in contact with water, or enveloped in earthy sediments.

One of the most interesting sections of the book is that devoted to the phenomena of sedimentation. In his numerous and beautiful experiments, M. Fayol has produced in miniature every peculiarity of the coal-field of Commentry. As a general conclusion, both from natural and artificial deltas, M. Fayol divides each into two parts, which he terms Alluvial and Neptunian respectively. The latter consists of beds inclined at angles of from 0° to 45°, and the former are spread over them horizontally, or nearly so.

In tranquil water the coarser materials are deposited in steep slopes, as if they had been tipped from a waggon; the finer sediments in agitated water are spread over greater distances and may be nearly horizontal. The dip of the beds increases with the coarseness of the materials, the feebleness of the current, the smallness and the tranquillity of the basin, and *vice versâ*.

Sometimes a third set of beds, nearly horizontal, and *below* the Neptunian part, may be observed.

Highly inclined beds of coarse grain, then, are likely to have been formed in lakes fed by Alpine torrents; horizontal beds of fine grain point to fluvio-marine conditions. Hence the inference that the irregular, inclined, and coarse beds of the coal-fields of Commentry have been formed in an Alpine lake; while the more extended, finer, and more horizontal strata of the northern French coal-field are ascribed to fluvio-marine conditions.

M. Fayol claims that there is not a single peculiarity of the coal formations which is not to be found in the deltas of the present day, and imitated in artificial deposits.

These experiments and observations on sedimentation have a value far beyond their immediate application to the coal-fields of Central France. They will be found of great value in explaining the general phenomena of stratification.

If M. Fayol's theory is correct, it follows that the inclination of the strata in the coal-field of Commentry is *not* due to subsequent earth movements, but is the original position of the Neptunian part of the delta. Consequently, he has to do battle with the geological axiom of the original horizontality of aqueous deposits.

M. Fayol goes into the history of this hypothesis, and points out that it was first formulated by Stenon, a native of Denmark, in 1669.

The fact that flat pebbles in inclined strata lie parallel to the bedding, is considered one of the strongest proofs. But, as we have seen, this is the natural position taken in beds originally inclined.

The horizontality observed in alluvial beds at the mouths of rivers is another supposed proof. These, however, are only the *horizontal covering* of the *inclined* Neptunian beds.

The regular thickness of marine beds, and the feeble inclination of the sea bottom, is thought to show that all beds must be nearly horizontal when first laid down. But a gentle inclination of the bottom does *not* prevent the formation of *steeply inclined* beds near the mouth of a river. Thus the bottom of the Mediterranean has a feeble slope, and yet, at the mouth of the Var, deposits, inclined at angles of from 25° to 30°, are formed. A similar inference is to be drawn from the experiments.

Nor do beds of vegetable matter at various heights in deltas *necessarily* imply horizontality; they are found at all inclinations between 0° and 40°, and can, as experiment shows, be formed by vegetation carried by streams.

The convenient hypothesis of movements of the earth's crust has, perhaps, been too freely invoked for the explanation of geological phenomena; it is well to have it thus brought home to us, that in some cases we may dispense with it.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

FRACTIONAL VALUES FOR π.

To the Editor of KNOWLEDGE.

SIR,—Will you allow me to submit to your readers what is, I believe, a new approximation for the number π, and which expresses the ratio of the circumference of a circle to its diameter more accurately than any other fractional approximation I have heard of?

Among the ancient Egyptians* the ratio was taken as $(\frac{4}{3})^4$, which is equal to 3·160,493,8 . . . . .

The true ratio being

3·141,592,653,589,793,238,462,643,38 . . .

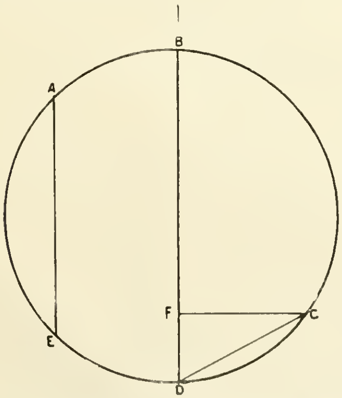
the Egyptian value shows an error in excess of ·018,901 . . . or about one-fiftieth part of the diameter.

Archimedes showed that π was less than $3\frac{1}{7}$, and greater than $3\frac{10}{71}$. After this achievement of the Greeks, no great advance was made towards the truth until the sixteenth century. The Hindus, about the year 500 A.D., used $\frac{3927}{1250}$ = 3·1416 as the ratio. This is near enough for all practical purposes, but is not sufficiently easy of construction.

In the sixteenth century a man named Adrian, a native of Metz, gave as the value $\frac{355}{113}$ = 3·141,592,9 . . . which is correct to the sixth decimal inclusive. But this is not much easier of construction than the Indian value.

For all ordinary purposes the best way to draw a straight line approximating in length to the circumference of a circle is to take three diameters *plus* one-fifth part of the side of inscribed square. We thus obtain a straight line equal to 3·141,421,356,237,3 . . . . .

This shows an error in defect of ·000,171,297 . . . . . or less than one five-thousandth part of the diameter. It is not necessary to construct with greater accuracy, but, nevertheless, whilst looking for a nearer coincidence, I one day lighted upon the following:



Let ABCDE be a circle, the diameter of which is taken as unity, and AE the side of an inscribed square; BD is any diameter; $FD = \frac{BD}{5}$ FC is drawn at right angles to BD, and meets the circumference at C. The points C and D are joined by the straight line CD.

Now if we draw a straight line equal to three times DC, *plus* one and a third of AE, *plus* six-sevenths of BD, we shall approximate with marvellous accuracy to the circumference of the circle.

Thus:

$$3\,DC + \frac{4\,(AE)}{3} + \frac{6\,(BD)}{7} = 3·141,592,685,22 \ldots$$

showing an error in excess of ·000,000,031,63 . . . . . or less than the thirty-millionth part of the diameter. By the above method, therefore, if it were possible to draw with perfect accuracy, an engraver might, in a few minutes, construct a straight line so nearly equal to the circumference of a given circle *that even in a diameter of thirty miles the error would be less than the sixteenth part of an inch.*

It is easily seen that in the above figure $DC = \frac{\sqrt{5}}{5}$; whilst $AE = \frac{\sqrt{2}}{2}$. Thus, since $\sqrt{5}$=2·236,067,977,5 . . . . .

and $\sqrt{2}$=1·414,213,562,4 . . . . .

$$\frac{3}{5}\sqrt{5} + \frac{2}{3}\sqrt{2} + \frac{6}{7} = 3·141,592,685,22 \ldots$$

I am, Sir,

Your obedient servant,

September 27th, 1890. GERARD DANIEL.

To the Editor of KNOWLEDGE.

DEAR SIR,—Will you inform me if there is anything to be done with a really good chronometer which has been badly magnetised through a visit to some electrical works, the proximity to the powerful magnets there employed causing an error of several seconds daily which cannot be rectified?—Yours truly,

C. PARKINSON.

[The watch may be demagnetised by placing it in a magnetic field produced by a coil through which a powerful alternating current is passing. The intensity of the correcting magnetic field should be at least as great as that which originally caused the derangement, and the watch should be slowly withdrawn from the coil through which the alternating current is passing. Mr. Common, in the *Observatory* for November 1889, gives an account of the demagnetisation of a chronograph watch which he had badly magnetised by going too near to a dynamo at work, so that from a rate of fifteen seconds gaining, a losing-rate of from five to six minutes a day had been caused. He took it to the chief engineer of the electric lighting works of Paddington Station, who placed it within a coil used for the purpose, through which an alternating current of about 140 volts was passing, and turned it about slowly, withdrawing it while doing so. The result was perfectly successful, and the watch at once returned to its old rate of fifteen seconds gaining.—A. C. R.]

THE WORD "BROAD."

To the Editor of KNOWLEDGE.

DEAR SIR,—The great English Dictionary now in course of publication is not only admirable for the abundance of information it contains, but also for the care with which its able Editor keeps within the limits of ascertained fact. One instance of this is found under the word *Broad*, the

* This appears from a calculation found in the Rhind papyri.—A. C. R.

various forms of which are given, and then the frank statement that "no related words are known, even in Teutonic, except its own derivatives: see Breadth, Brede."

After such a confession by this high authority, I shall surely offend no prejudices by venturing to suggest some "related words" which appear to have been overlooked.

By the simplest form of metastasis [*cf. brydde = bird*] we get to the word *Board*, a broad extended surface of wood, a word for which the Dictionary offers nothing better than tentative suggestions as to its correlations. The Dutch word *bord* is used for a plate or trencher, that being an extended surface; and the old English word *Bred* for "a board, or tablet," gives another congener of *Broad* or *Board*. But what about the word *Bread*? This word is left to surmises by the Dictionary, because it did not occur to the writer that *bread* derived its name from the shape of the *broad* flat cakes which were the first representatives of the loaf. The failure to recognize this alliance is the more remarkable when we remember that the word *bread* survived in its primitive sense (when applied to ships' biscuits) down to the 18th century. A similar word is *Brad*, which the Dictionary itself defines as "a thin *flat*tish nail"; its *broad*ened shape being the cause of its name.

The common interchange of *l* and *r* accounts for the old word *Blad*, "a firm *flat* blow," and this brings us to *Blade*, a word always expressive of that which is *broad*, whether it be a blade of grass, the blade-bone, or the blade of a knife, sword, or paddle. This is clearly seen in the southern Scotch use of the word *blade* for the broad outer leaves of cabbage, lettuce, &c.; and in the German restriction of *blatt* to a leaf, while *laub* (*i.e.* leaf) is applied to foliage in general. And do not the words *Plate*, *Platter*, a *Plot* of ground, and a grass-*Plat*, give us other variants of the interchangeable letters *p-l-t*, *b-l-t*, *b-l-d*, *b-r-d*, in the sense of extended surface?

The well-known change of *p* to *f* brings the word *Flat* itself into the series; for is not every flat surface a broad or extended one? Surely no philologist of the narrowest school will deny that the Greek πλατυς is basically connected with the word *plate*, and that both are allied to the Sanskrit *prath*, "to extend." The Sanskrit word for *broad* is *prithu*, in which we find the labial, semi-vowel, and dental, just as in the European languages; and *prithwî* is the name of the earth because of its extended surface.

The framework of all the words here adduced is—

Labial.		*Semi-vowel.*		*Dental.*
f	-	l	-	t
p	-	l	-	t
b	-	l	-	t
b	-	l	-	d
b	-	r	-	d
p	-	r	-	t

It is not pretended that these words are derived from each other, but that they are most certainly basically connected together, and may fairly be used to modify the statement that "no related words [of Broad] are known, even in Teutonic, except its own derivatives."

Frederic Pincott.

WET DAYS IN SUMMER.

To the Editor of Knowledge.

Sir,—Looking through the records of rainfall at Greenwich since 1841, I have met with a fact which I do not remember to have seen pointed out before, and which seems to deserve the attention of meteorologists, farmers, and others.

It is, that the character of June, as regards rain, is to some extent a key to that of the rest of the season (meaning by "season" the four months June to September). More often than not, if June is wet, the three other months (viewed as a whole) are wet; if dry, dry. We may, if we like, frame a statement which has wider, and nearly universal, application, thus:—

Where we find a wet June we find a wet season; where a dry June, a dry season.

Here we include those cases in which the excess or defect of June makes the season wet or dry, though the remaining three months may be average, or dry (in the case of excess), or wet (in the case of defect).

I have measured wetness by the number of wet days, meaning by a wet day one on which at least one-tenth of an inch has fallen. A wet month, season, or other period, will be understood to mean one with more than the average number of wet days.

If anyone will take the trouble to make out a curve of the number of wet days in June, and another of the wet days in the whole season, or in June–September, he will find a remarkable correspondence.

Those forty-nine seasons may be classified in the following way, which brings out very well the matter to be explained:—

	Reckoning	
	By wet days.	By all days of rain.
A. Wet seasons with June wet—		
a. June wet and rest of season wet ...	12	13
b. ,, ,, ,, average	2	1
c. ,, ,, ,, dry ...	1	5
B. Dry seasons with June wet	3	2
C. Dry seasons with June dry—		
a. June dry and rest of season dry ...	16	16
b. ,, ,, ,, average	1	3
c. ,, ,, ,, wet ...	1	1
D. Wet seasons with June dry	1	2
E. Seasons with June average—		
a. Wet seasons	6	2
b. Dry seasons	3	3
F. Average seasons—		
a. June wet	1	0
b. June dry	2	1
	49	49

I have added a column in which all days of recorded rain are considered, and the results seem still better than in the first column.

Thus, excluding Class *E* (with June average), we have in *A* and *C* the instances proving the rule; while *B*, *D* and *F* contain the exceptions.

Accordingly we find: in the first column, 33 instances, 7 exceptions; in the second column, 39 instances, 5 exceptions. Further, it appears that, in 12 years out of 19 (or nearly 2 out of 3), with June wet, the rest of the season was wet; and in 16 years out of 21 (or about 4 out of 5), with June dry, the rest of the season was dry. (The corresponding figures for all days of rain are 13 out of 21, and 16 out of 23.)

It will be asked, Do these facts at all help us, at the end of June, to forecast more definitely the character (number of wet days) of the next three months? I think they do.

If we group together all the Junes which had the same number of wet days, and compare, for each group, the

corresponding numbers of wet days in July to September, we find these latter not alike, of course, but varying within limits. Their averages form, on the whole, an ascending series (ascending with the number of wet days in June). And by studying these averages and their variations, one is able, I think, to limit the range of probability not inconsiderably. I will not trouble you with details (which may be had, if desired).

Last June was very wet; it had 10 wet days. Our forecast for the three months would have been 22 (average and most probable number). The actual number is, I think, 19. The season falls under the category *A*, *b*. We might not always, of course, be so near the truth.

It would be interesting to know whether the above rule holds good elsewhere than in Greenwich, and this letter, if you are disposed to publish it, may perhaps usefully lead to observations on the subject.

The well-known old saying about St. Swithin's day is, of course, easily exploded by facts of observation. But the widespread impression (which may have had to do with the origin of that and similar sayings) that wet weather appearing about the time of the summer solstice tends to persist a considerable time, is perhaps to some extent explained by the facts above indicated.

Allow me to add another feature which has struck me in this inquiry. We seem to have a conspicuously wet June near the beginning (or end) of each decade; *i.e.* at about ten years intervals (say 10+2). This is the case with 1848, 1860, 1871, 1879, and 1890; and all the higher maxima (say above 9 wet days) are thus included. Taking the Chiswick record, we may add the years 1830 and 1838.

I am, Sir, yours truly,
Alex. B. MacDowall.

THE ASTRONOMICAL AND PHYSICAL SOCIETY OF TORONTO.

To the Editor of Knowledge.

Dear Sir,—In the interest of your Canadian and more distant subscribers, of whom four at least are members of this Society, I venture to invite your attention to a subject which has been discussed by us, and which we trust will commend itself to your favourable consideration.

Under the most toward circumstances, Knowledge does not reach us earlier than about the 23rd of the month of issue. The last number was delivered to us on the 23rd of September, the day of arrival. As you will readily see, the greater portion of the astronomical memoranda edited by Mr. Herbert Sadler is therefore of no value to us. This we much regret, and it has occurred to us that we might be allowed to suggest the propriety of so amending Mr. Sadler's plan as to permit his notes to extend over the earlier half of the following month at least. We have also noticed that, as a rule, the events predicted are those which will be visible in England only, thus omitting many which would be visible, for instance, on this Continent. But we do not do more than mention this, as we believe you give up to this branch of information all the space you can spare.

That you may form some idea of the objects of the Society with whose permission I thus address you, I beg to enclose some printed matter which includes a clipping from one of the Toronto papers in which appear notices respecting our meetings, which are held at intervals of two weeks. The second paper by Mr. Gore will be read at an early day. At our last meeting portions of your article relative to the work of Mr. Higgs, of Liverpool, were read and commented upon by Mr. Elvins and Mr. Miller, who have made a special study of the solar spectrum and have written upon the subject. On Tuesday next, one of our members will read a paper prepared with a view to illustrating in a practical manner Mr. Higgs's method, and will show how photographic plates, by means of dyes, can be made sensitive to the less refrangible rays.

Yours very truly,
G. E. Lumsden,
Corresponding Secretary.

Toronto, Canada, 1st October 1890.

[Perhaps the best way to meet Mr. Lumsden's suggestion would be to bring Knowledge out ten days earlier. Mr. Sadler will in future include some of the more remarkable phenomena observable in America and India. Subscribers in the Australian colonies do not receive Knowledge till the month is entirely past. It is encouraging to learn that the articles are found sufficiently interesting to be read and discussed at such colonial meetings.—A. C. R.

THE FACE OF THE SKY FOR NOVEMBER.

By Herbert Sadler, F.R.A.S.

THE increasing number of solar spots and faculæ shows that the long-delayed minimum has at last been passed. Conveniently observable minima of the variable star Algol occur on the 3rd at 8h. 7m. p.m.; on the 6th at 4h. 54m. p.m.; on the 23rd at 9h. 47m. p.m., and on the 26th at 6h. 38m. p.m.

Neither Mercury, Venus, nor Mars can be seen at all to advantage this month. Mercury is in superior conjunction with the sun on the 17th; the very great southern declination (28°) of Venus militates against her observation at the beginning of the month, when she sets one hour after the sun, while she only sets about ten minutes after that luminary at the end of November. As we intimated in the last number of Knowledge, our ephemeris of Mars is discontinued on account of his increasingly diminishing diameter and brightness, and his proximity to the sun.

Jupiter must be looked for very early indeed in the evening for any details of the markings of the disc, phenomena of the satellites, &c. to be seen. He sets on the 1st at 9h. 58m. p.m., with a southern declination of 19° 58′, and an apparent equatorial diameter of $38\frac{3}{4}''$. On the 30th he sets at 8h. 28m. p.m., with an apparent equatorial diameter of $35\frac{3}{4}''$, and a southern declination of 18° 56′. Jupiter describes a direct path in Capricornus during the month, but does not approach any star brighter than the 7th magnitude.

Saturn does not rise till midnight on the last day of November, so we defer an ephemeris of him till next month. Uranus is also for all practical purposes invisible to the amateur observer.

Neptune is excellently placed for observation, rising on the 1st at 5h. 43m. p.m., with a northern declination of 19° 42′, and an apparent diameter of $2\frac{1}{2}''$. On the 30th he rises at 3h. 15m. p.m., with a northern declination of 19° 33′. He is in opposition to the sun on the 27th, when he is distant from the earth about $2{,}679\frac{1}{4}$ millions of miles (solar parallax 8″·80). At last year's opposition, using the same parallax, he was about half a million miles less distant from us. He describes a short retrograde path in Taurus about midway between the stars E. and W. in that constellation.

November is a very favourable month for shooting stars. The most marked displays are the *Leonids* on November 13th and 14th, the radiant point being in R.A. 10h. 0m.

Decl. +23°. The radiant point rises about a quarter past 10 P.M. The *Andromedes* occur on the 27th, the radiant point being in R.A. 1h. 40m. Decl. +43°. The radiant point, which is circumpolar, souths at 9h. 13m. P.M.

The moon enters her last quarter at 4h. 13m. P.M. on the 4th; is new at 1h. 38m. P.M. on the 12th; enters her first quarter at 0h. 45m. P.M. on the 19th, and is full at 1h. 23m P.M. on the 26th. There will be a partial eclipse of the moon on the afternoon of the 26th, but as it is invisible in this country, and as only the two thousandth part of the lunar disc will be obscured by the true shadow, no further details need be given. The 7th magnitude star 5 Geminorum will disappear at 6h. 59m. A.M. on the 1st (three minutes after sunrise) at an angle of 145° from the vertex, and reappear at 8h. 4m. A.M. at an angle of 296° from the vertex. The 6th magnitude star 42 Leonis will disappear at 3h. 2m. A.M. on the 6th at an angle of 340° from the vertex, and reappear at 3h. 46m. A.M. at an angle of 267° from the vertex. The $5\frac{1}{2}$ magnitude star 39 Ophiuchi will disappear at 4h. 33m. P.M. on the 14th at an angle of 138° from the vertex, and reappear at 5h. 34m. P.M. at an angle of 267° from the vertex, the moon having set at Greenwich at the time. This is a very pretty double star, the components being of $5\frac{1}{2}$ and $7\frac{1}{2}$ magnitudes, and 12″ apart. The colours are orange and blue. At 5h. 3m. P.M. the same evening the 7th magnitude star B.A.C. 5831 will make a near approach to the lunar limb at an angle of 203° from the vertex. At 4h. 42m. P.M. on the 18th the $5\frac{1}{2}$ magnitude star 33 Capricorni will disappear at an angle of 148° from the vertex, and reappear at 5h. 35m. at an angle of 246° from the vertex. The 5th magnitude star 33 Piscium will make a near approach to the lunar limb at 3h. 43m. P.M. on the 21st (in sunlight) at an angle of 171° from the vertex, and the $5\frac{1}{2}$ magnitude star B.A.C. 17 will disappear at 5h. 59m. P.M. the same evening at an angle of 125° from the vertex, and reappear at 7h. 5m. P.M. at an angle of 268°. The 6th magnitude star 26 Ceti will make a near approach to the lunar limb at 8h. 22m. P.M. on the 22nd at an angle of 208° from the vertex, and at 11h. 0m. P.M. the same evening the $6\frac{1}{2}$ magnitude star 29 Ceti will disappear at an angle of 223° from the vertex, and reappear fifteen minutes later at an angle of 250°. The $6\frac{1}{2}$ magnitude star 35 Ceti will disappear at 1h. 6m. A.M. on the 23rd at an angle of 177° from the vertex, and reappear at 2h. 2m. A.M. at an angle of 312°. At 7h. 25m. P.M. on the 24th the 5th magnitude star 38 Arietis will make a near approach to the lunar limb at an angle of 176° from the vertex. The 7th magnitude star B.A.C. 2151 will disappear at 2h. 37m. A.M. on the 29th at an angle of 58° from the vertex, and reappear at 3h. 34m. A.M. on the 28th at an angle of 343°. The $6\frac{1}{2}$ magnitude star B.A.C. 2514 will disappear at 6h. 27m. A.M. on the 30th at an angle of 148° from the vertex, and reappear at 7h. 25m. A.M. at an angle of 271° from the vertex.

Whist Column.

By F. S. HUGHES, B.A.Cantab.

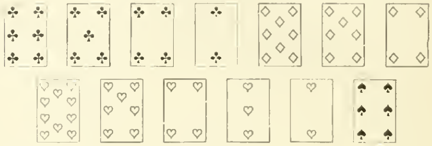
THE TURN-UP CARD.

BEGINNERS cannot be too often reminded of the great importance of remembering the turn-up card. Really good players often err in this respect, and even though they do not actually forget the trump card, neglect opportunities of fine play afforded by the information that may be given by means of it.

In many cases the dealer may be enabled to inform his partner of the position of trumps by playing a higher card instead of the turn-up. Of course he must be careful that his partner will not mistake the motive, as for example, by thinking that he is echoing when he has only three trumps.

An illustration is furnished by the following hand, which also shows how a player whose hand on paper appears hopelessly bad may by his skill in placing cards be the means of saving the game.

HAND No. 15.



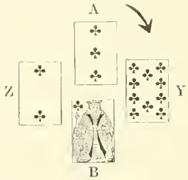
Z's Hand.

Score—Three all.

Z turns up the 4 of diamonds.

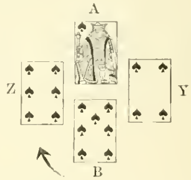
NOTE.—A and B are partners against Y and Z. A has the first lead; Z is the dealer. The card of the leader to each trick is indicated by an arrow.

TRICK 1.



Tricks—AB, 1; YZ, 0.

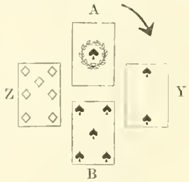
TRICK 2.



Tricks—AB, 2; YZ, 0.

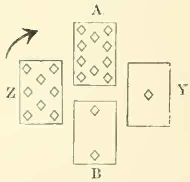
NOTE.—From his lead, A has not more than four clubs.

TRICK 3.



Tricks—AB, 2; YZ, 1.

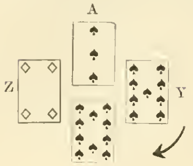
TRICK 4.



Tricks—AB, 2; YZ, 2.

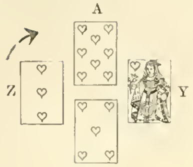
NOTE.—*Trick* 3.—Y has completed a call. Z can count the spades in the respective hands. B's lead of the 7 was obviously the penultimate, so that he has three cards of his suit remaining. The three is marked in A's hand, and he can have no more, as otherwise he would have led spades in preference to a weaker four suit (see *Trick* 1). Therefore Y has two spades remaining, and if B holds a ten ace over him, which is likely, Y must lose both his spades, if A leads through him. Z is bound to respond to his partner's call, but if Y goes on with trumps Z will be unable to ruff another spade. On this hypothesis, he reasons that if Y has only five trumps to one honour A B are almost sure to make two tricks in trumps and two more in spades, and thus go out by honours. Z therefore trumps with the seven and leads the eight, thus showing Y that he has still a trump—the turn-up—and can trump a spade, if Y wishes to give him another ruff.

TRICK 5.



Tricks—AB, 2; YZ, 3.

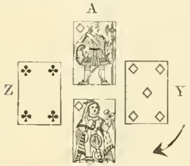
TRICK 6.



Tricks—AB, 2; YZ, 4.

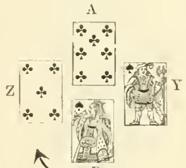
NOTES.—*Trick* 5.—Y grasps the situation and gives Z a ruff. *Trick* 6.—If A B are two by honours and B has the best spade, the game is still lost unless Y can make three tricks in hearts and clubs. Z therefore leads a heart in case Y wants to finesse.

TRICK 7.



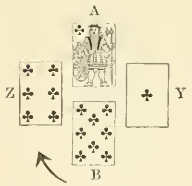
Tricks—AB, 3; YZ, 4.

TRICK 8.



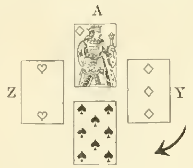
Tricks—AB, 4; YZ, 4.

TRICK 9.



Tricks—AB, 4; YZ, 5.

TRICK 10.



Tricks—AB, 5; YZ, 5.

Y makes the remaining tricks, and

Y Z WIN THE GAME.

A's Hand.	B's Hand.
D.—Kg, Kn, 10.	D.—Qn, 2,
C.—Qn, Kn, 7, 3.	C.—Kg, 9, 8.
H.—Kg, 9, 8.	H.—Kn, 6, 5.
S.—Ace, Kg, 3.	S.—Qn, 10, 8, 7, 5.
Y's Hand.	**Z's Hand.**
D.—Ace, 9, 6, 5, 3.	D.—8, 7, 4.
C.—Ace, 10.	C.—6, 5, 4, 2.
H.—Ace, Qn.	H.—10, 7, 4, 3, 2.
S.—Kn, 9, 4, 2.	S.—6.

Remarks. It is very difficult to lay down general rules as to the degree of strength required to justify a call for trumps. In no part of the game is the personal equation of players more manifest. Amongst really good players there would probably be some diversity of opinion as to whether Y was strong enough to call. However, the knowledge of Y's hand that Z obtained at the end of the third trick enabled him to see that if Y had not two honours, or more than five trumps, the game was certainly lost, unless Y had the winning spade, or he himself could make another ruff. Z therefore acted on this hypothesis.

If Y had been uncertain whether Z had another trump, it would have been too risky to lead a spade, as he thereby lost the chance that B might finally be compelled to lead spades up to his second-best guarded.

G. SHAW.—The penalty for a revoke can only be claimed at the end of the hand.

Chess Column.

(CONDUCTED BY I. GUNSBERG.)

THE STEINITZ GAMBIT.

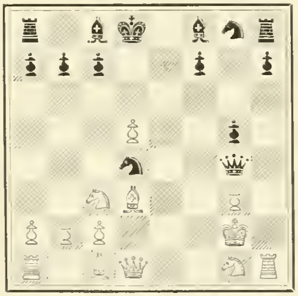
By G. H. D. GOSSIP.

WHITE.	BLACK.
1. P to K4	1. P to K4
2. Kt to QB3	2. Kt to QB3
3. P to B4	3. P×P
4. P to Q 4	4. Q to R5 ch
5. K to K2	5. P to Q4 or (A)
6. P×P	6. Q to K2 ch
7. K to B2	7. Q to R5 ch
8. P to Kt3	8 P×P ch
9. K to Kt2	9. Kt×P
10. P×P	10. Q to Kt5
11. Q to Ksq ch	11. K to Qsq

Zukertort played B to K2 at this stage in the last game of his match with Steinitz, but soon got into difficulties and lost.

12. B to Q3	12. P to KKt4

BLACK.



WHITE.

These moves occur in a game between Steel and Blackburne.

13. Kt to K4! best

Here Mr. Steel played 13. Q to K3, and lost. Had he, however, played the move I suggested above as best, he would speedily have gained an irresistible attack; for suppose now

13. P to KB3! best

(If 13. B to K2. 14. Q to B3 &c.: or if 13. P to KR3, 14. B×P ch, &c.).

14. Q to B3! best

This is much stronger than Q to B2, the move suggested by the Chess Editor of the *Australasian.*

	14. Kt to B4
15. B×P	15. P×B

If 15. B to K2, 16. B to KB4, &c.; or if 15. B to Kt2, 16. B to KB4, White having in either case a vastly superior game. If 15. B to Q3, 16. B×P ch, Kt×B or (*a*); 17. Q×Kt ch, K to Q2; 18. Q×R, winning easily.

(*a*) 16. K to Q2; (if 16. K to Ksq, White has a certain road to victory by 17. Kt×B ch, P×Kt; 18. B to QKt5 ch with a winning position); 17. B to QKt5 ch, P to B3; 18. P×P ch, again winning easily.

16. Q×R and White wins

The moves, therefore, of 11. K to Qsq and 12. P to KKt4 for the defence, introduced by Blackburne in this form of the Steinitz Gambit, are therefore unsound, and the defence of 6. Q to K2 ch, 7. Q to R5 ch, recommended by MacDonnell and Duffy, and considered best by the Editor of the *Book of the London Tournament* (1883), is inferior, as the subjoined analysis (approved by Herr Csank, of Vienna) will show. Repeating the ordinary moves in the Steinitz Gambit.

WHITE.	BLACK.
1. P to K4	1. P to K4
2. Kt to QB3	2. Kt to QB3
3. P to B4	3. P×P
4. P to Q4	4. Q to R5 ch
5. K to K2	5. P to Q4
6. P×P	6. Q to K2 ch
7. K to B2	7. Q to R5 ch
8. P to Kt3	8. P×P
9. K to Kt2! (best)	9. B to Q3! (best)
10. Q to Ksq ch! (best)	10. QKt to K2! (best)

If 10. Q to K2; 11. B to KKt5, P to B3; (if 11. Q×Q; 12. R×Q ch, QKt to K2; 13. P×P, followed by Kt to K4, &c.); 12. P×Kt, P×B; 13. B to QKt5, P to QKt3; 14. Kt to Q5, Q×Q; 15. R×Q ch, K to Bsq best; (if Kt covers, then R×Kt, followed by Kt×P ch, &c.); 16. P×P, with a superior game. Compare Steinitz's notes on Steel's analysis in the *Book of the London Tournament* (1883), p. 61:—

11. P×P	11. Q×QP
12. Kt to KB3! (best)	

This and the next six moves of White constitute the Steel attack in the Steinitz Gambit, which Mr. Steel suggested as stronger than the continuation 12. R to R4 &c., adopted by Steinitz in a game, which he lost, in the London Tournament, to Tschigorin. For if now—

12. Q to Kt3,

and there does not appear to be any better move at Black's disposal, then follows:—

13. B to K3	13. Q×P
14. B to Q3	14. B to QKt5
15. B to Q4	15. P to KB3
16. R to QKtsq	16. B×Kt
17. B×B	17. Q×QRP
18. R to QKt5.	

BLACK.

WHITE.

and the game is dismissed in the *Book of the Tournament*, p. 61, with merely the remark "that White has a strong attack."

The subjoined analysis, however, will show that White can obtain a winning advantage in about half a dozen moves, *e.g.*

It is obvious that Black has only two moves at this juncture to avoid immediate loss, viz., P to QKt3 and Q to R3.

Now, if firstly:

	18. P to QKt3
19. Q to K2	19. Q to R3! (best)

If 19. Q to R6; 20 B to Kt4, and White must win, wherever the Queen goes, *e.g.* if (I.) 20. Q to R7; 21. R to Ksq, P to QR3; 22. B×Kt, K to B2; 23. R to Kt3, &c. If (II.) 20. Q to R5; 21. R to Ksq, followed by B×Kt, &c. Or if (III.) 20. Q to R3; 21. B×Kt, &c. Nor could Black play 19. Q to R5; on account of White's reply 20. B to Kt4, followed by R to Ksq, &c.

20. KR to QRsq	20. Q to Kt2! (best)
21. P to Q6! (best)	21. P×P

If 21. B to Kt5; 22. B to K4, &c.

22. B to K4	22. Q to Ktsq

If 22. Q to B 2; 23. B×R, Q×B; 24. KR×QRP, followed by the capture of the QKtP, and Black's game is utterly broken up.

23. B×R	23. Q×B
24. R×QKtP and must win.	

For if now: 24. Q to Q4; 25. R×QRP, &c.; or if 24. B to Kt2; 25. Q to Kt5 ch, B to B3; 26. R to Kt8 ch, K to B2; 27. R×Q, B×Q; 28. R (from QRsq)×QRP, B to B3; 29. R to Q8, B to K5; 30. B to Kt4, and Black's game is untenable, since he must either lose a piece or permit the fatal advance of the White QBP.

If secondly:

	18. Q to R3
19. Q to K2	19. B to KKt5

If 19. Q to Q3; 20. B to Kt4, Q to Q2; 21. P to Q6, P×P; 22. R to Q5, with a terrible attack. For if now 22. Q to K3; 23. Q×Q, B×Q; 24. R×QP, K to B2; 25. R to Ksq, B to Kt5; 26. B to B4, &c.

If 19. P to QKt3, the position is resolved, by a transposition of moves, into that already examined above.

If 19. KKt moves; 20. R to Ksq, followed by 21. B to Kt4, and White wins.

If 19. K to Bsq, 20. R to QRsq, followed by B to QKt4, &c.

If 19. B to Q2; 20. KR to Ksq, Q to Q3!; 21. B to Kt4, P to B4; 22. QB×P, Q×P; 23. B×Kt, B×R; 24. B×B ch, K to B2; 25. B to QB4, Kt×B!; 26. B×Q ch, Kt×B; 27. Q to B4 and wins.

20. R to QRsq	20. Q to Q3! (best)
21. B to Kt4	21. B×Kt ch

If 21. Q to Q2 or Qsq; 22. R×KtP, followed by 23. P to Q6, and White wins.

22. Q×B	22. Q to K4 or Q2 or Qsq
22. R to Ksq or R×KtP	

and again White has a winning position.

(A.)

The following variations of the Defence 5. P to KKt4 in the Steinitz Gambit are worthy of attention:—

1. P to K4	1. P to K4
2. Kt to QB3	2. Kt to QB3
3. P to B4	3. P×P
4. P to Q4	4. Q to R5 ch
5. K to K2	5. P to KKt4

Although this Defence is seldom played, it deserves notice.

6. Kt to Q5 or varn.	6. K to Qsq
7. Kt to B3	7. Q to R4
8. K to B2	8. B to Kt2
9. P to B3	9. KKt to K2 or (B)
10. B to K2	10. P to B3
11. Kt×KtP	11. Q×Kt
12. QB×P	12. Q to R5 ch
13. P to Kt3	13. Kt×Kt
14. P×Kt!	14. Q×B
15. P×Q	15. Kt to K2
16. B to B3 and wins.	

The above moves occurred in a game in the last Divan Tourney between Gossip and Loman.

(B.)

9. Kt to B3

Played by Tarrasch against Burn in the Frankfurt Tourney; but Steinitz prefers KKt to K2, as above analysed.

10. Kt×Kt	10. B×Kt
11. P to K5	11. B to Kt2
12. P to KKt4	12. P×P *en pass.* ch
13. K to Kt2	13. P to KR3
14. P×P	14. Q to Kt3
15. B to Q3	15. P to B4
16 Q to B2! with an excellent game.	

Variation on White's 6th move.

6. Kt to B3	6. Q to R4
7. P to KKt4	

Steinitz prefers this to 7. Kt to Q5, which, however, yields White a capital attack.

	7. Q to Kt3
8. P to KR4	8. P to B3
9. P to Q5	9. QKt to K2
10. Q to Q4	10. B to Kt2
11. Q to B5 with a strong attack.	

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